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Experiments with rail motor coaches in Spain,

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As the interesting trials of rail motor coaches carried out in Spain since the last International Congress in Madrid in 1930 are not known by my foreign colleagues, I think it will be useful to report briefly the personal investigation I have just carried out into them.

In the report will be found observations which I think will be considered original.

I. — PREVIOUS REPORTS.

Financial dangers of complete electrification.

The International Railway Congress Association appointed my friend, Mr. Garcia-Lomas, and myself to report on Question XIX (*Electrification of secondary lines*) on the agenda of the eleventh Congress held in Madrid in 1930 (1).

In this report, after describing all the applications on which we had been able to obtain information, we were obliged to point out how few they were, owing to the expenditure the complete electrification of a line involves, the interest upon which is proportionally a heavier charge upon the working than the economies obtained, especially when the lines are definitely secondary ones, according to the classification laid down in the questionnaire of the XIth International Congress in the following terms :

By secondary railways should be understood those of which the standard or narrow gauge lines, while forming part of the general system, connect less important centres and of which the characteristic features of the engine stock, general equipment, speed and traffic are inferior to those of the main line railways.

We had already criticised the unreasoning enthousiasm which appears to exist among many engineers who, deceived by the indisputable advantages of electric traction and by the success obtained in some applications, have not hesitated to propose its extension to secondary lines.

We even went as far as to point out in

(1) See *Bulletin of the Railway Congress*, February 1930, p. 665.

an article published in the *Revista de Obras Publicas* of Madrid, 15 May 1923 issue, that electrification would be ruinous and almost preposterous for a line known as the Madrid to Valencia direct line, which the interested regions loudly called for, pretending that the shortening (lineal, but not virtual) by some kilometres obtained, thanks to the use nearly throughout of gradients of 1 in 33, which made electric traction almost essential, would justify an expenditure of 100 000 000 pesetas.

Our reasoning, simple, it is true, but not disputable, was the following :

The electrification of a line, standard gauge, and even single track, would involve a considerable additional expenditure (2).

The interest on this additional expenditure, at 5 %, would be 7 800 pesetas per km. (12 550 pesetas per mile).

With this expenditure it would be possible to purchase 111 metric tons of coal (3). With this coal, 12 trains could be run daily with steam traction.

Consequently, even supposing that the current were obtained without charge, electrification would not be satisfactory economically except when the traffic exceeded 12 trains per day and, as the price of current increases (it would be necessary to increase the number of trains per day in proportion in order to justify a similar expenditure on first cost.

We did not ignore the fact that electrification reduces the cost of maintenance of the permanent way and rolling stock, and even of staff, but it is nonetheless true that the interest increases very heavily the operating rates and even with current at 0.07 peseta the kilowatt-hour (4) it is indispensable for the number of trains to be considerably greater than 12 daily and they must run at regular intervals to make up for the millions sunk in the electrification as a whole.

It is therefore obvious that certain lines electrified without full consideration will suffer from the crushing burden of the interest on this expenditure, which was incurred too lavishly and without due reflection.

Other economical traction methods.

For this reason, for a long time endeavours have been made in all countries to try other methods to reduce the cost per train-kilometre.

As long ago as 1929, in our Madrid Congress report, we thought it would be useful to examine the different systems tested :

1. Petrol rail cars with mechanical drive and 30 to 60-H.P. motors, seating 30 to 50 passengers.

2. Steam rail cars, either single or articulated, the former in some cases able to haul a trailer; seating capacity, from 70 to 150 passengers.

3. Electric accumulator rail cars able to haul one or two trailers according to the case, generally of 100 to 150 H.P., with a total seating capacity similar to those mentioned previously.

4. Petrol-electric rail cars of 100 to

(2) At this period we calculated it at 156 000 pesetas per km. (251 000 pesetas per mile) without including the power stations (steam or hydraulic), nor the transport of the current up to the line.

(3) We estimated the price of coal at 70 pesetas per ton and the fuel consumption at 25 kgr. per train-km. (88.7 lb. per train-mile), this being the average figure for the North of Spain and the Madrid-Saragossa-Alicante Railways.

(4) The minimum price obtained by the North of Spain Railway.

300 H.P., of high seating capacity, and capable of hauling one or two coaches.

5. Oil-electric (Diesel or semi-Diesel) cars of considerable power (300 to 500 H.P.), capable of hauling 3 or 4 vehicles, forming a real light train.

I do not propose to reproduce particulars of the operating savings obtained abroad with each of the above types as these vary with the prices of fuel in each of the countries in question, but it will be as well to repeat the conclusions of our report drawn up in 1929 :

Conclusions of our report :

1. « Complete » electrification of secondary lines, meaning by this expression the electrification of the driving stock, such as the construction of the system for the distribution and the external supply of energy, is only possible, in general, from an economic point of view, in countries or regions where electric energy is widely distributed, and may be obtained under very advantageous conditions which favour the growth of the population and a corresponding increase in the traffic.

2. In the use of special systems for the service of certain traffic particularly that of passengers, « incomplete » electrification, that is to say, the electrification exclusively of the engine stock, either by the generation in that stock of the necessary electrical energy (Diesel-electric or gas-electric motor coaches) or by the accumulation of energy supplied by an external source (traction by accumulators) may be a solution for both secondary and main railways serving sparsely populated districts, or which are faced with the competition of other forms of transport, when the investment of considerable capital in « complete » electrification is not justified by the density of the passenger traffic or by the economies, which, taking all the factors into account, the substitution of electric traction for steam traction is able to effect, even for goods traffic.

These conclusions of our report were accepted by the Congress after discussion in almost the same terms as those reproduced above.

This shows that by 1929 we had pointed out, and the Congress agreed, the advantages of rail motor coaches as compared with full electrification on lines with light traffic.

In spite of these valuable conclusions, the majority of railways preferred to await the results of the rail motor coach trials which were in hand throughout the world.

In Spain, however, a certain number of railways, through the falling off of traffic, did not hesitate to put into service rail motor coaches of different types.

All obtained satisfactory results; in some cases the results were extraordinarily good.

I have investigated each working on the actual lines in question and a summary of the results of my personal enquiry will, I think, be of great value. I would like to thank the Managers of the Companies in question for the information they were good enough to give me.

II. — TESTS IN SPAIN SINCE 1930.

The financial difficulties of the Spanish railways have become more marked since the Madrid Congress and the companies have devoted much attention if only to lightening them.

Since that time, not only the repercussions of the economic collapse of the whole world and the consequent falling off of traffic, but also the demands of the *railwaymen*, accentuated by the new republican regime and in addition the

great development of road competition which, thanks to the good conditions of most of our main roads has resulted in regular road services of coaches and lorries over distances of 300 to 500 km. (185 to 310 miles) (5) being introduced, have seriously affected our country.

For these reasons, the Spanish railways, alarmed by the losses suffered and by the growing deficits which have already caused a number of lines to be abandoned (6), are looking into, and even testing out, the different types of rail cars described below.

They will be described as concisely as possible.

Ybern system rail-cars on the Villena to Alcoy and the South of Spain Light Railways (7).

These two small Companies under the same control consist of 135 km.(84 miles) of metre gauge line.

They are running today 4 vehicles which, as from the 25 January 1931, have run a daily mileage of 770 km.(480 miles).

The original features of the system are :

1. The use of motors of the usual type of car engine : they used first of all 15-H.P. Renault petrol engines. In the three new vehicles under construction, 20-H.P. Chevrolet motors have been chosen in preference as they are more powerful and cheaper (3 000 pesetas instead of 10 000), and it is hoped that the petrol consumption will be 16 litres per 100 km. (5.7 Imp. gallons per 100 miles), instead of the 23 litres per 100 km. (8.1 Imp. gallons per 100 miles) used by the Renault.

So far, preference has been given to the car engines because they are considered to be cheaper to buy as being mass produced and consequently their repairs are much cheaper and defective parts can be replaced by the interchangeable parts supplied at low prices by the agents of these firms, to be found everywhere.

It is thought that these engines which stand up very well under the shocks they suffer in road vehicles and which have been perfected by long and universal use, offer greater guarantees of durability, and are easier to handle and repair than the best makes of Diesel at present available.

As, however, the fuel economy of the latter is very much in evidence at the present time, Mr. Ybern, in the new vehicles he has put into service, has fitted Diesel engines while retaining the second feature which is the following :

2. In these coaches the inventor claims that two frames must be used in each vehicle, one supported on the other; the motor sub-frame, and the main vehicle frame carrying the wheels and axles.

The motor sub-frame, which is like the frames used on road motors, carries the

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(5) A great part of the fish landed in Galicia and Guipuzcoa is sent to Madrid and Barcelona by lorry. There are road passenger services from Madrid to Salamanca, Grenada, Bilbao, Valencia, and Hendaye, which are faster and cheaper than by train. In Morocco we are also the victims of possibly even more serious competition.

(6) The Ministry of Public Works has even issued a decree in accordance with which a delay of one month is prescribed, so that bodies or districts interested in the continuance of the services of such railways can offer to share these deficits; otherwise the Government disinterests itself in these railways and definitely suspends the running of trains.

(7) This type of motor coach has been patented by its inventor who has called it the « auto-voie ».

engine rigidly secured to it; it is supported by the main frame on the steel wheels through elliptical springs which absorb the shocks at rail joints; in addition shock absorbers are fitted between the motor frame and the body. Finally the main frame is carried on a set of springs secured to the roller bearing axle boxes which were fitted to reduce the tractive effort required.

The other principal features of the three latest vehicles are :

Chevrolet motor, 6 cylinders, 20 H.P.

Capacity : 40 passengers, 26 seated and 14 standing.

Maximum speed, 60 km. (37.3 miles) an hour, normal speed 50 km. (31 miles).

Petrol consumption : 16 litres per 100 km. (5.7 Imp. gallons per 100 miles), which it is expected will be reduced to 13 litres (4.6 Imp. gallons) with a Soles carburetter.

Lubricating oil consumption: 800 grammes per 100 km. (2.83 lb. per 100 miles).

Strong and comfortable body 7.88 m. (25 ft. 10 1/4 in.) long, 2.26 m. (7 ft. 5 in.) wide and 2.40 m. (7 ft. 10 15/32 in.) high.

Tare weight : 5 000 kgr. (11 020 lb.).

The interior is lighted electrically from a self-charging battery which also supplies current for a headlight and two lights, red and green, in front, and three red lights at the rear.

The steering wheel is used to apply the brake blocks acting on the steel wheels. The auto brakes are only used when the brake blocks acting on the wheels are out of action.

The axle gear is designed for a maximum running speed of 60 km.(37.3 miles) an hour, which increases the useful power of the motor.

In trains conveying the mails, these vehicles haul a three-compartment trailer, two of the compartments being reserved for the Post and luggage. In the other trains if there is a rush of passengers, instead of the postal trailer mentioned above an ordinary vehicle is attached, which merely has its oil boxes replaced by roller bearing boxes.

In the report of the Directors of these Companies, dated February 1932, it is stated that during the eleven months of working (26 January to 31 December, 1931) and in spite of several cases of sabotage, the cost per train kilometre was :

Petrol.	0.1320	peseta
Oil	0.0260	»
Running repairs	0.0190	»
Driver	0.0395	»
Total . . .	0.2165	peseta

Through using these railcars, 273 022 train-km. (169 650 train-miles) were run in 1931, carrying 125 819 passengers whereas with steam locomotives in 1930, 147 431 train-km. (108 390 train-miles) were run with 85 075 passengers.

The reduction of costs, although considerable, has not been as great as expected because the Ministry of Public Works has not allowed the redundant staff to be paid off; the management is hopeful, however, of making further economies as soon as it is allowed to work its lines under the regulations governing tramways instead of being obliged to follow those for main line railways, which there is no longer any reason for doing.

Petrol rail motor cars on the Bidassoa metre-gauge Line.

Three petrol rail motor cars of the Verney type are in service.

The first has been in service since the

16 July 1931 and has run more than 30 000 km. (18 600 miles) in a year without anything going wrong except some dynamo defects.

The motor is a Panhard 4-cylinder sleeve valve engine. The normal engine speed is 1 800 revolutions per minute. It develops 78 H.P. at 2 200 revolutions.

The four wheels are 0.70 m. (2 ft. 3 1/2 in.) in diameter and the axles are 4.20 m. (13 ft. 9 3/8 in.) apart.

The car is heated by the exhaust gases.

The body is 8.40 m. (27 ft. 6 3/4 in.) long, the length over buffers being 9.30 m. (30 ft. 6 in.). The width is 2.25 m. (7 ft. 4 19/32 in.) and seats are provided for 33 passengers. The empty weight is 7 200 kgr. (15 870 lb.) and the useful load is 3 500 kgr. (7 720 lb.).

The vehicle can haul a trailer weighing 5 000 kgr. (11 000 lb.). The maximum speed is 50 km. (31 miles) an hour. The consumption is 30 l. per 100 km. (10 Imp. gallons per 100 miles) when running alone, and 36 l. per 100 km. (12.7 Imp. gallons per 100 miles) when hauling a trailer. When running alone the coach can run at the following speeds up the gradients given :

1 in 38 at 31 miles per hour,
1 in 24 at 26 miles per hour,
1 in 19 at 15 miles per hour,
1 in 9 at 8.7 miles per hour ([8]).

In view of the excellent results given by the first vehicle, the Company bought two others which were put into service on the 19 June 1932. Two railcars cover the passenger service and the third is spare.

Each vehicle runs three trips of 56 km. (35 miles) that is an average of 156 km. (97 miles) daily.

Two light trailers weighing about 4 tons for use with the rail motor cars on days with heavy traffic have been built at the Beasain shops (Compagnie Auxiliaire de chemins de fer).

The new service is giving satisfaction to the public, which is beginning to give up using the motor omnibuses which had taken away most of the passengers formerly using the company's steam trains. In any case the rail motor cars had made it possible to reduce the cost of the train-kilometre from 2 pesetas to 0.70, the cost of staff working the trains and light repairs inclusive.

I have personally watched the excellent and regular running of these rail motor cars although I was surprised to see petrol engines used, seeing that today the recent progress made in Diesel engines definitely shows a fuel economy. I have gone into the matter with the builders who appear to be inclined to substitute gas oil for petrol and are looking into the question of the use of some new Diesel engines manufactured at Lille.

Rail motor cars of the Malaga Suburban Railways.

This metre gauge Company, in 1931, put into service a train of three units (fig. 1) the design and construction of which is due to the very distinguished engineer of this Company, Mr. De Jouve, who was good enough to facilitate in every way my enquiries.

The centre motor vehicle is fitted with a semi-Diesel *Maybach* motor made at Friedrichshafen, of 150 H.P. at 1 300 r. p. m., 4 speeds in both directions and compressed air starting.

Seats are provided for 12 first-class

([8]) These rail motor cars were supplied by the « Société centrale de chemins de fer et d'entreprises », 122, boulevard Malesherbes, Paris (17e).

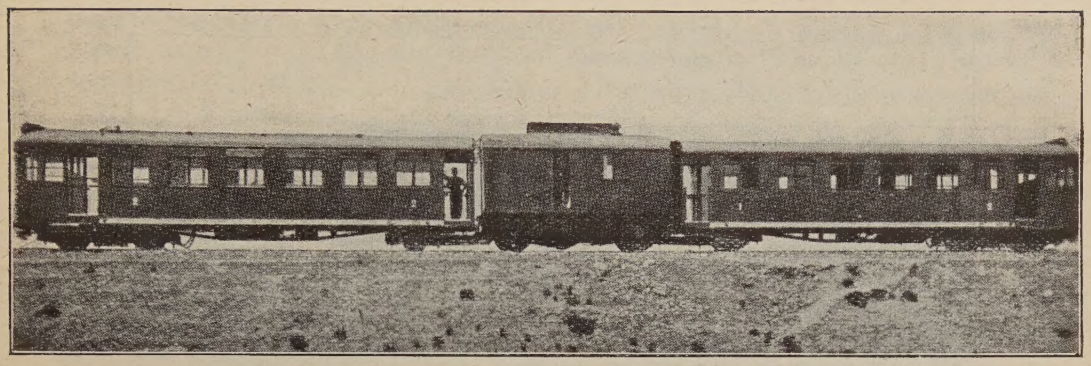


Fig. 1. — Light train with central motor unit (Diesel-mechanical), of the Malaga-Velez Line.

and 84 second-class passengers, and in addition there is room for 10 passengers to stand in the vestibules; i.e. a total of 128.

The unit is driven from either end.

The weight of this train when empty and when loaded is 35 and 40 tons respectively.

This train can also haul a coach weighing 15 tons.

	Per kilometre.	Peseta.	Per mile.	Peseta.
Fuel oil	0.526 litre	0.1683	*0.186 Imp. gall.*	*0.2708*
Motor lubricating oil .	0.033 kgr.	0.0117	*0.116 lb.*	*0.0188*
Vehicle lubricating oil	0.026 kgr.	0.0031	*0.092 lb.*	*0.0050*
			Total	*0.2946*

The results are satisfactory and the competition of motor road vehicles has been stopped. It has however been found that the distance of 3.50 m. (11 ft. 5 25/32 in.) between the centres of the axles of the motor vehicles is excessive for the very sinuous lay-out of this metre gauge line with curves of very small radius.

In spite of this however the distance of 36 km. (22.4 miles) from Malaga to Velez with 17 halts or stops is run in 67 minutes. Without stops the time taken is only 42 minutes, 5 of which are taken to run through the harbour and the city. This distance includes a gradient of 1 in 83 which is 1 200 m. (3/4 mile) long and another of 1 in 50 for a length of 800 m. (1/2 mile).

The speeds are :
40.4 miles on the level,
28 miles on a gradient of 1 in 83,
21.7 miles on a gradient of 1 in 67,
17.4 miles on a gradient of 1 in 50.

The outer bogies have triple suspension; the bissel wheels of the coaches and those of the motor vehicle have double suspension.

The costs for fuel oil and lubricating oil are :

Petrol rail motor cars for the Majorca Railways (Balearic Islands) (9).

During the first months of 1931, on this metre-gauge system, 3 rail motor cars

(9) Information supplied by the Engineers of this Company and by the Beasain Works.

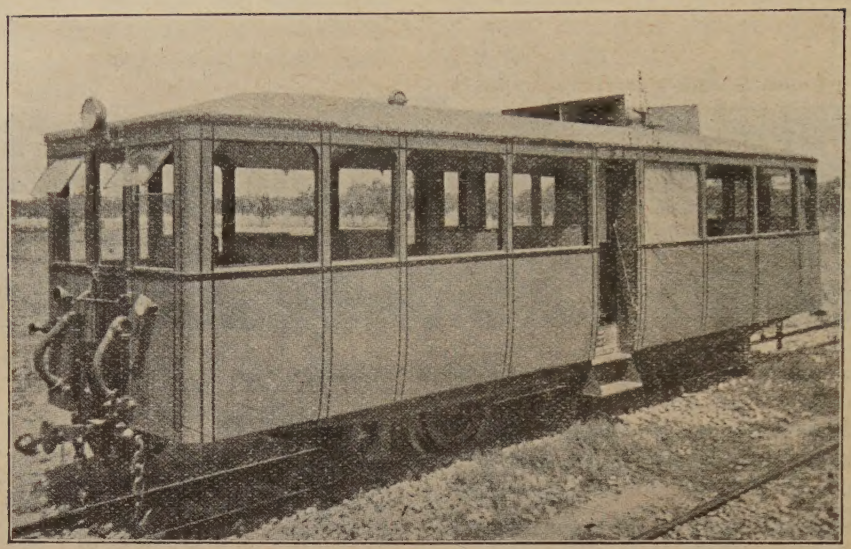


Fig. 2. — Dion-Bouton petrol rail motor car (Beasain type), of the Majorca Railways (Balearic Islands).

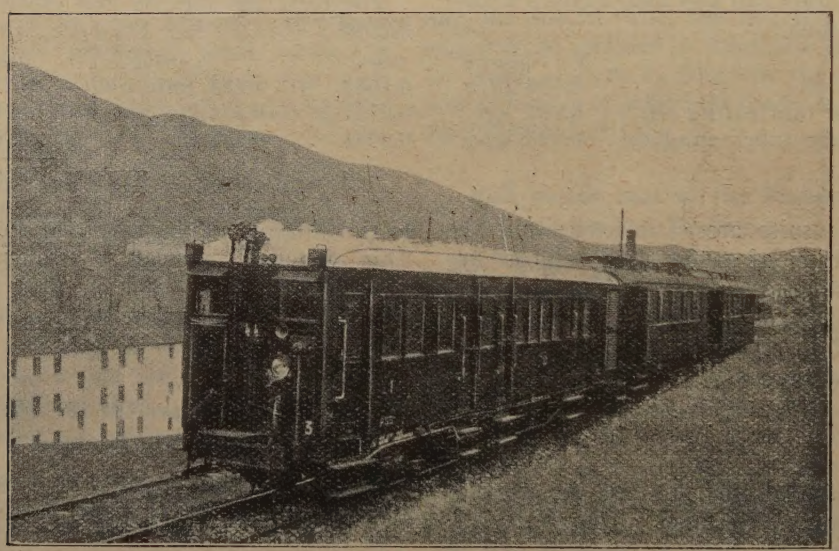


Fig. 3. — Train hauled by 200-H. P. Diesel-electric rail motor car, San-Sebastian to Pampelune Line.

built by the Beasain Works of the « Compagnie Auxiliaire de chemins de fer », were put into service.

The petrol motors are of the de Dion-Bouton type, 4 cylinders, 82 H.P. at 1 750 r.p.m.

These coaches can ascend gradients of 1 in 71 at 50 km. (31 miles) an hour; the speed falls to 30 km. (18.6 miles) when hauling two vehicles of 6 tons.

The petrol tank, containing sufficient petrol to run 100 km. (62 miles), like the motor, is placed under the frame between the two wheels, the distance apart of which is 4.25 m. (13 ft. 11 5/16 in.). The cooling is done by air taken from the roof of the vehicle.

The length over buffers is 11.67 m. (38 ft. 3 1/2 in.).

The body is 2.45 m. (8 ft. 1/2 in.) wide and built of metal covered plywood, and this has made it possible to reduce the total weight to 12 300 kgr. (27 110 lb.).

It provides seats for 38 passengers, two driving compartments and a lavatory. Communication is given with the trailer vehicles by vestibules.

In spite of some gradients of 1 in 77 on the 28-km. (17.4 miles) line from Palma to Inca, worked by these three coaches for the last year and a half, the average price of the train-kilometre (including small repairs and cleaning) has been reduced by two thirds thanks to the use of these rail motor cars.

The Engineers of this Company have prepared with great care a very interesting comparison between costs of the trains worked by steam and those for the rail motor cars. We give here only the most noteworthy of the average figures.

—	Steam trains.		Petrol trains.	
Metric (*English*) tons hauled	66 (*65*)		9 (*8.6*)	
Average hourly speeds	34 km. (*21.1 miles*)		32.5 km. (*20.2 miles*)	
Seats available	182		88	
	Pesetas per train-km.	*(train-mile).*	Pesetas per train-km.	*(train-mile).*
Cost of fuel	0.570	*0.917*	0.290	*0.467*
Lubricating oil	0.100	*0.161*	0.044	*0.071*
Other materials	0.045	*0.072*	0.0024	*0.0039*
Repairs	0.222	*0.357*	0.013	*0.021*
Cleaning and maintenance	0.126	*0.203*	0.005	*0.008*
Water	0.052	*0.084*	»	»
Driving staff	0.248	*0.400*	0.070	*0.112*
Repairs to rolling stock	0.0023	*0.037*	0.008	*0.013*
Operating staff	0.222	*0.357*	0.050	*0.080*
Total	1.5873	*2.588*	0.4724	*0.7759*

Cost per metric ton hauled	0.014 peseta	0.20 peseta
Cost per seat available	0.0087 —	0.0056 —

It should be noticed, however, that the steam trains haul more vehicles with an average weight of 66 t., and provide 182 seats whereas the rail motor cars only haul one or two vehicles weighing 6 t. with 32 seats, i.e. an average of 88 places, which is generally sufficient for the traffic.

It is nonetheless true that the cost per place offered is less by about one third, with rail motor cars, which confirms the economic advantages of their use.

Steam rail cars, Sentinel type, of the Zafra to Huelva Railway (5 ft. 6 in. gauge).

This is the only trial of steam rail cars carried out in Spain with the same type of Sentinel boilers as described in our report to the International Congress, 1930, mentioned previously.

The first vehicle purchased in August 1928 by the Zafra to Huelva Company worked the service from the 10 June 1929 to the 3 November 1930, and ran 111 404 km. (69 220 miles). It was only stopped twice, each time for 7 days, in May and in August 1930, for general repairs and to replace 20 burnt boiler tubes. The average daily mileage was 266 km. (165 miles).

The total weight of the car in service is 32 850 kgr. (72 480 lb.), 22 000 kgr. (48 540 lb.) being carried on the motor bogie.

The number of seats available is 35 plus 4 in the vestibule.

The power of the motor is 100/125 H.P.

The fuel consumption is 2.60 kgr. per km. (9.22 lb. per mile); the coal used is screened Asturias coal.

The boiler water tank is refilled once each trip of 133 km. (83 miles).

The car which easily attains a speed of 70 km. (43.5 miles) an hour, will run at 30 km. (18.6 miles) over 1 in 50 gradients.

The cost, in pesetas, has been :

	Per train-km.	Per train-mile.
Coal	0.180	*0.290*
Water and lubricating . . .	0.020	*0.032*
Driving staff . .	0.105	*0.169*
Train staff . .	0.052	*0.084*
Cleaning & maintenance . . .	0.068	*0.109*
Total . . .	0.425	*0.684*

The firebox, costing £ 150 is in perfect condition ([10]).

Diesel-electric rail motor car of the metre-gauge San-Sebastian to Pampeluna Railway ([11]).

This line, 91.6 km. (57 miles) long is very heavy; it climbs from sea level to San-Sebastian [6 m. (20 feet)] up to the 649 m. (2 130 feet) level, and then descends to Pampeluna which is at 448 m. (1 470 feet) above sea level. There are gradients of 1 in 40 for a distance of 3 km. (1.9 miles) and curves of 80 and 90-m (4 and 4 1/2 chains) radius, with very many tunnels of narrow section, which make steam traction unpleasant and costly.

The Company consequently decided to try 3 Beardmore Diesel-electric rail motor cars, of 200 H.P., which could replace the regular passenger trains; these rail motor cars had to be able to haul two carriages weighing 16 tons.

([10]) Information supplied by the Manager of this line and by the « Construcciones Metalicas del Llobregat Company » which represents the « Sentinel-Cammell Company » in Spain.

([11]) As this is the type of rail motor car which seems to me to be the most interesting, I have studied it in greater detail and it seems to me useful to report the detailed observations made.

The characteristics of the rail motor cars adopted are :

30 seats, 12 first and 18 third-class, lavatory and luggage compartment.

Empty weight	33 000 kgr.	*(72 750 lb.)*
Loaded weight	35 800 kgr.	*(78 920 lb.)*
Axle weight :		
Bogie, Diesel end	9 500 kgr.	*(15 760 lb.)*
Bogie, passenger end	7 150 kgr.	*(20 940 lb.)*
Length over buffers	15.02 m.	*(49 ft. 3 in.)*
Maximum width	2.18 m.	*(7 ft. 2 in.)*
Maximum height	3.25 m.	*(10 ft. 8 in.)*
Hourly speed on the level	60 km.	*(37.3 miles)*
Type of motor :		
6-cylinder, high speed Diesel.		
Diametre of cylinders	165 mm.	*(6 1/2 inches)*
Piston stroke	228 mm.	*(9 inches)*
Number of r. p. m. of motor	600/1 250.	
Brake-H. P. of the motor	200.	
Weight of the motors :		
Diesel motor and its base	1 910 kgr.	*(4 210 lb.)*
Dynamo and excitor	2 142 kgr.	*(4 720 lb.)*
Radiator and fans	658 kgr.	*(1 450 lb.)*
Weight of the electric equipment :		
Casings over the electrical apparatus, including control gear and cables	1 020 kgr.	*(2 250 lb.)*
4 electric traction motors and gears	4 200 kgr.	*(9 260 lb.)*
Accumulators and controllers	1 200 kgr.	*(2 640 lb.)*

Since February 1930, these three cars have worked the passenger service between San-Sebastian and Pampeluna, running a daily distance of 200 km. (124 miles); during the 4 summer and autumn months the three cars were constantly in service, two in regular train working, and the third for additional trains or for double heading.

The distances run by these three cars were up to 30 June 1932, 98 384, 124 366 and 115 050 km. (61 134, 83 493, 71 490 miles) respectively, without anything going wrong nor repairs, with an average daily mileage of 200 km. (124 miles).

In order to realise the degree of utilisation obtained with these rail motor car trains, it is as well to examine the services which were worked in 18 months, from the 1 January 1931 to the 30 June 1932 :

—	Days in service.	Reserve. Days.	Small repairs. Days.	Heavy repairs. Days.	Distance run. Km. (*miles*).
Rail motor car No. 1.	366	32	19	130	56 894 (*35 353*)
Rail motor car No. 2.	409	63	12	63	71 395 (*44 363*)
Rail motor car No. 3.	442	52	9	44	77 545 (*48 185*)
Total. . .	1 217	147	40	237	205 824 (*127 901*)

Weight of trains :

The booked train was composed of :

Rail motor car .	35 850 kgr.	*(79 035 lb.)*
2 passenger coaches . .	32 000 kgr.	*(70 550 lb.)*
Total . .	67 850 kgr.	*(149 585 lb.)*

But the normal passenger train during the largest part of the year was :

Rail motor car .	35 850 kgr.	*(79 035 lb.)*
Passenger coach	16 000 kgr.	*(35 275 lb.)*
Brake van . .	8 500 kgr.	*(18 740 lb.)*
Total . .	60 350 kgr.	*(133 050 lb.)*

In summer two rail motor cars are sometimes coupled together and haul four passenger coaches or three coaches and a van.

The average figures for *fuel and lubricants* were :

	1930	1931
Gas oil :		
Per train-km.	0.8288 kgr.	0.8635 kgr.
(Per train-mile)	*(2.9420 lb.)*	*(3.0650 lb.)*
Per tkm.	0.0175 kgr.	0.0176 kgr.
(Per Engl. ton-mile)	*(0.0630 lb.)*	*(0.0633 lb.)*
Oil for lubrication of Diesel engine (Vacuum oil) (12) :		
Per train tkm.	0.0564 kgr.	0.0477 kgr.
(Per train-mile)	*(0.2000 lb.)*	*(0.1693 lb.)*
Per tkm.	0.0010 kgr.	0.0010 kgr.
(Per Engl. ton-mile)	*(0.0036 lb.)*	*(0.0036 lb.)*

The cost per train-kilometre which, with steam traction was 1.536 pesetas, was in this way reduced to 0.711 peseta including the expenditure for the locomotive and shop men, the average figure for the two years' service.

Speed. — On the level the speed reaches 70 km. (43.5 miles) an hour; the minimum speed on the level and shunting is 8 to 10 km. (5 to 6.2 miles) an hour.

Brakes. — The rail motor car is fitted with vacuum brake and hand brake. The vacuum is produced by a motor driven exhauster. There are two brake cylinders : one 21″ in diameter and one 18″.

Driving. — The vehicle is controlled like a tramway by one man, a seat being provided.

Daily maintenance. — The line which is 91 km. (56.5 miles) long has only one workshop, at the intermediate station of Andoain.

The rail motor cars are in continual service for at least 3 months; six months are often run without any repair being necessary.

During the service the daily maintenance is done by two drivers at each end of the line, one at San Sebastian and the other at Pampeluna, who, during the time the rail car stops between arrival and departure, carry out the outside cleaning of the Diesel, check its running, clean the oil filters, and lubricate the axle boxes and bearings; the whole takes an hour and a half.

Every 15 days, i.e. after 2 500 km. (1 550 miles) the driver, assisted by a labourer, empties the crank case and the

(12) The Vacuum Diesel engine lubricating oil is drained off after 2 500 km. (1 550 miles), and after being filtered and treated is again used. In this way an economy of 40 % has been obtained, which it is hoped to increase still further.

gas-oil tank and replaces the used oil by new oil; this takes two hours of work per rail motor car every fortnight.

Every week the electrician from the repair shop goes to the terminal station to clean and repair the electric equipment of the vehicle; he examines the collectors and brushes and tops up the accumulators; this requires 4 hours of work per car.

Normal overhaul period. — Every three months, i.e. after 18 000 to 20 000 km. (11 185 to 12 430 miles), each rail motor car is brought into the workshops.

As regards the *Diesel motor*, the heads and pistons are taken out and cleaned, as are the valves; the connecting rod bearings are examined; the fuel injectors are cleaned and the engine is re-erected. This requires two fitters and a helper ([13]).

The *accumulators* are gone over, and fully charged and the density of the electrolyte is equalised.

The *bogies* and *brakes* are examined and the vacuum brake is tested.

Finally the *whole of the vehicle* is examined and cleaned.

These last operations are carried out during the 4 days required to overhaul the Diesel. The fifth day the rail motor car resumes its regular service for at least a further three months.

Heavy repairs. — After two years service the Diesel is taken completely down and the whole of its parts are overhauled; the water and oil radiators are taken apart and the generator, the excitor and electric motors are gone over with care, as is the battery and the whole of the electric equipment; the bogies are taken down as are the brakes. Finally the carriage is repainted and completely checked over.

This work takes a month and a half; 15 to 20 days for 2 fitters with their assistants and 8 days for the electrician. The repairs to the bogies and body are no greater than those required for a metal coach after two years' service.

Complete overhauls have been given to two rail motor cars after running 50 000 km. (31 000 miles); the third vehicle was gone over after 103 000 km. (64 000 miles). As the staff becomes more experienced, the minimum mileage between heavy repairs will not be less than 100 000 km. (62 000 miles).

The cost of the stores for these heavy repairs is not greater than in the case of light repairs.

Regularity of service. — This has been remarkable; after a few mistakes at the beginning, the drivers recruited from among the best workmen but not specialised in train working on the line very quickly became familiar with the engines although these are so complicated.

Summary.

The Manager of this line, my very distinguished friend, Mr. Horacio de Azqueta, has not hesitated to sum up the information which he has been so good as to supply in the following terms :

I have obtained with Diesel-electric traction during more than two years' experience a very high coefficient of utilisation of the rail motor cars, a maintenance as simple as inexpensive, less damage and defects of service than on a railway completely electrified; the suppression of smoke and fumes;

([13]) The stores used for these ordinary overhauls is insignificant : 12 paper joints; 12 rubber rings for the water tube pipes, 6 asbestos joints for the cylinder heads and 6 asbestos rings for the exhausts. Occasionally one or two piston rings and one or two copper washers for injectors and heads must be supplied.

ease of driving; great elastificity of service; long runs without having to take additional supplies of fuel; the suppression of water columns; readiness of the rail motor cars for immediate service; the increase in the periods of running without requiring overhaul or cleaning; very small repair costs; finally a very great economy of fuel. The advantages over steam traction are therefore obvious.

Rail motor cars on the San-Sebastian to Hendaye Electric Railway.

This convincing experience caused the same engineer, Mr. Azqueta, who is also Manager of the small metre-gauge railway between San Sebastian and Hendaye [22 km. (13.7 miles)], to substitute for the complete electric traction of this line installed at the beginning of 1912, Diesel-electric rail motor cars.

This Company has, with this object in view, opened a competition between the builders or this type of rolling stock and, according to the proposals submitted, there would be an appreciable operating saving as compared with the present equipment. It is true that the latter was in need of modernisation, but the fact remains that this Company, having a completely electrified line, gave preference to Diesel-electric rail motor cars as the result of experience on the San-Sebastian to Pampeluna line, eloquently demonstrates the advantages of these small electric travelling power stations over the traction by overhead wires and trolleys, even when in existence.

This Company therefore submittel to the Ministry of Public Works a proposal to purchase 5 motor cars seating 50 passengers and carrying 25 standing, with 150-H.P. Diesel-electric engine, to run at 70 km. (43.5 miles) per hour on gradients of 1 in 83.

I consider this fact as a radical stage in the evolution of the electrification of secondary railways, as it brings out the economic and even technical error committed in the case of all lines with reduced traffic, electrified by overhead equipment, as the interest on this costly installation bears so heavily on the annual expenditure.

Rail motor cars of the North of Spain Railways.

Except on the Zafra to Huelva line, all the other railways which have carried out rail motor car trials are metre-gauge lines.

But, as the reduction of receipts is quite as alarming on the main line Spanish railways, these companies have long considered with the greatest interest the progress of automobile traction.

The North of Spain Company, 3 785 km. (2 351 miles) long, set up a technical commission presided over by Mr. José Garcia-Lomas (14), Engineer attached to headquarters, to study this problem fully.

The very fully documented report of this commission is definitely in favour of the use of rail motor cars for a very large number of secondary lines and even certain sections of the main lines.

The Commission considers that the acquisition of about 100 rail motor cars of different types, the cost of which would be about 27 million pesetas, would make it possible for the Company to obtain not only a reduction of the operating costs but also to recover a part of the passengers which the public road motor services have taken from it.

The figures resulting from this investigation appear to show that the profit to

(14) Mr. Garcia-Lomas is the very distinguished colleague who collaborated with me in drawing up the report on the Electrification of secondary railways mentioned above.

be obtained from this expenditure would be equivalent to an annual return of about 31 %.

The Commission suggested, however, that a test should be made by inviting tenders for :

7 four-wheeled rail motor cars of a light type with mechanical transmission;

3 heavy type rail motor cars with Diesel motor and mechanical or electrical transmission as preferred by the builder.

This was done and 8 proposals for each of the two types of rail motor cars were received.

According to the specifications not only were the technical conditions to be fulfilled laid down but also quite special financial conditions were imposed, since the cars were to be paid for in 5 years against a hire agreement for this period with option of purchase, the extra rate of interest being 7 %.

The result of this competition has been announced :

The North of Spain Railway Company have given the construction of the 10 coaches to the same firm, the *Geathom* Company, which was formed by a consortium of several companies which could produce the necessary guarantees, as follows :

7 light 4-wheeled rail motor cars with 43 seats, M. A. N. Diesel engine of 140 H.P. and mechanical transmission; the tractive effort at the wheel tread is 6 610 kgr. (14 570 lb.). The price of each is 218 633 pesetas, including the interest for repayment in 5 years.

3 double-bogie rail motor cars with 4 driving wheels, 101 seats, M. A. N. 350-H.P. Diesel motor; electric transmission; tractive effort at the rim 5 470 kgr. (12 060 lb.). Price of each vehicle : 472 753 pesetas, including interest for payment in 5 years.

The North of Spain Company proposes to introduce the first services without trailers, so as to provide ultra-light and fast trains [the speed expected reaching 90 km. (56 miles)] on the section from Madrid to Avila and Segovia, crossing the Guadarrama with long gradients of 1 in 59 and 1 in 50.

On sections with easier gradients the same rail motor cars will be capable of hauling a trailer.

Rail motor coaches for the Madrid-Saragossa-Alicante (M. Z. A.). Company.

This Company, with a system of 3 670 km. (2 280 miles), has also set up to study the problem, a committee of engineers, which is presided over by the Chief Engineer, Mr. Santiago.

After a very careful enquiry among the different companies and builders abroad and an investigation on the spot at the more important European works, the M. Z. A. Board accepted the conclusions of the report and asked for tenders for the supply of :

4 Diesel-electric rail motor cars, type A, able to haul a light coach;

4 Diesel-electric cars, type B, not to haul a trailer;

3 light trailer vehicles, of which one for the Post Office.

The maximum speeds of the rail motor cars type A, without a trailer are to be 100 km. (62 miles) an hour on the level and 75 km. (46.6 miles) on gradients of 1 in 59.

These speeds are to be reduced to 90 and 50 km. (56 and 31 miles) for the rail motor cars of type B.

The units are to be fitted with automatic compressed air brakes, electric lighting and heating.

The buffer and draw gear, though light, should be such that the cars can

be coupled with the other vehicles of the M. Z. A.

The vehicles are to have 2 bogies, with seats for 16 second-class and 64 third-class passengers and have lavatory and luggage compartments.

This rolling stock will be paid for at the rate of 10 and 15 % the first year, then 12.5 % per half year over a total period of 3 years, from the date of reception in Spain.

This shows that the engineers who made this investigation and have been good enough to let me see their report, definitely pronounce for Diesel-electric traction and have not considered their present vehicles as suitable for use as trailers. They propose to introduce a complete service of rail motor cars on the Madrid-Aranjuez-Cuenca line 200 km. (124 miles) long, on which steam traction is costly and slow, owing to the very difficult section between Aranjuez and Cuenca.

The are confident of obtaining operating savings exceeding 50 % which will make it possible to pay off the purchase of the new rolling stock very quickly.

III. — PRELIMINARY CONCLUSIONS.

The investigation into these trials and those carried out in France with the « Micheline », the Diesel-Renault on the French State Railways and the « Pauline » on the Midi ([15]) made it possible for me to draw up the following preliminary conclusions :

Ybern system rail cars.

The addition to a vehicle of the ordinary type of a road vehicle petrol motor suggested by Mr. Ybern, or better still a Diesel, motor is ingenious and economical.

It has been applied on the short standard gauge line from Sevilla to Carmona [43 km. (26.7 miles)], and the same is being done on the line from Villacañas to Quintanar [25 km. (15.5 miles)].

This idea has also been considered by the Commission of the North of Spain Railway, which had also considered the application of motors to existing vehicles, but the engineers of this company decided not to do this because the alteration of the old coaches into rail motor cars was almost as costly as purchasing rail cars if it was intended to obtain the maximum output of the motors. This leads me to believe that if this simple idea has not been carried out so far as I know, in Switzerland and in Germany, by the motor builders who are most interested in extending their custom, it is because it is difficult and costly to adapt the motors to frames not designed to receive them.

For short distances and lines, the existence of which is uncertain, it is necessary to find an easy solution of low cost, but it is to be feared that the maintenance and repair of these improvised rail cars will cancel out the economy made on the purchase price.

Petrol rail motor cars.

The results obtained on the Bidassoa and Majorca lines show, it is true, that the cost of the train-kilometre is reduced by half in comparison with a steam train. But it is also shown that the progress in manufacturing Diesel engines makes it possible today to get from these engines an efficiency of 33 to 35 %, whereas that of petrol engines does not exceed 22 %; moreover the price of gas-

([15]) An account of which I have given in the September 1931 number of the review *Ferrocarriles y Tranvias.*

oil is very much lower than that of petrol; so it seems that the saving of fuel with a Diesel exceeds in many cases 50 %.

Consequently the superiority of this motor is no longer disputed; it also has done away with the fire risk which is to be feared with petrol engines.

Automotor trains of the Malaga type.

The arrangement of Mr. de Jouve is original and gives good results; it can be applied to narrow gauge lines with light rolling stock capable of being coupled together.

But for the standard gauge railway with its heavy vehicles it would be necessary to increase the power of the motors beyond measure and the economy obtained by the use of existing rolling stock would be annulled by the greater cost of purchasing the motors and especially of fuel. It seems to me preferable that the motor vehicle should be completely separate and that it should haul separate vehicles, as in the case of the locomotives. In this way any danger of not being able to use the whole train is avoided in the case of damage to any part of it, one of the defects of combined arrangements of this type which have been tested many times.

Steam rail motor cars.

In spite of the operating economies obtained in England with the 919 Sentinel rail motor cars in use and confirmed in Spain by the experience on the Zafra to Huelva Railway, it is none the less true that even that great Company, the London and North Eastern Railway, which uses 85 rail motor cars of this type, leans today towards the Diesel-electric system.

It must not be forgotten that with the steam locomotive the efficiency of fuel with difficulty reaches 15 %, so that the Diesel can give an economy of 65 % on the cost of fuel for the same useful horse power.

The steam locomotives ought therefore only to be used for heavy passenger and goods trains; they cannot compete with the Diesel in the case of light trains.

Diesel-electric cars.

The experience of two years on the San-Sebastian to Pampeluna line confirms what we forecasted in 1929 when writing our report for the Madrid Congress of 1930.

The Diesel-electric motor cars, the advantages of which have been proclaimed by the engineer Mr. de Azqueta who introduced them into Spain and which we recalled to attention above, have been recognised as necessary as soon as motors of 200 H. P. are needed. There are even companies who prefer electrical transmission even for 100-H. P. cars as it has so many advantages in working.

To sum up, I have formed the opinion that, in face of automobile competition, the methods of operating secondary railways ought to be transformed and that their out-of-date steam locomotives should be reduced to hauling too heavy trains.

The companies who will not, or who cannot, do so rapidly will soon be ruined through the growing defection of the public who will leave the railway for the road, as they have gone from the theatre to the cinema.

To complete my investigation, I consider it is indispensable to visit the manufacturers and to see the rail motor cars used in Switzerland and in Germany where more experimental work is being done on the question.

I propose to do this and will report the result in due course.

Madrid, August 1932.

[624 65 (.495)]

Note on some concrete arched structures,

by R. DESPRETS,
Professor at the University of Brussels,
Chief of the Constructional Designing Office of the Belgian National Railway Company.

We believe it would be interesting to give some brief notes with reduced scale drawings and photographs of a number of concrete arched bridges, comprising under and over-line crossings, which have been designed and built within recent years by the Belgian National Railway Company in connection with the construction of new lines.

Line from Brussels (Midi) to Ghent (St.-Pierre).

The Pede Viaduct.

The Pede viaduct on the new line from Brussels (Midi) to Ghent (St.-Pierre) is situated at about 5 miles from Brussels on the Ghent side, within the commune of Itterbeek, and at about 1.2 miles short of the intersection of the new line with the Ninove road. It crosses a fairly flat shallow valley, the rail level being at about 20 m. (65 1/2 feet) above the bottom of the valley (photo No. 1).

The sub-soil below the natural ground level consists of strata of various materials : sandy clay, peat of poor consistency, resting upon a bed of clay of variable thickness. Below this bed is a stratum of running sand of fairly considerable depth which finally itself rests on compact clay (fig. I).

Having regard to the excessive compressibility of the bad upper layers and to the insufficient prospects of stability which an embankment would have presented under these conditions, it was decided from the start of the study of the problem to traverse the valley by means of a viaduct and the choice fell upon a viaduct constructed in brickwork (photo No. 2).

The complete view of the latter is given in figure II. It comprised 16 semi-circular arches of 28-m. (92 feet) span grouped in 4 series of 4 arches separated by bastion piers. The arch vaults were of the « hingeless » type built in Boom bricks (Klinkaert) and they sprang from horizontal skewbacks for the entire depth of the arch. The spandrels were lightened over the piers and bastion piers by secondary arches also semi-circular. The abutments were lightened by arched openings.

Foundations. — The most difficult problem to be solved was that of the foundations for the piers and abutments.

In the first scheme the foundations were to be placed in the bed of lenticular clay at about 10 m. (33 feet) below the natural ground level, the method of execution (before the war) being by means of caissons sunk with the use of compressed air.

In a first contract after the war, foundations on ferro-concrete piles were also to be considered, the bases of the piers being connected together by a grillage of reinforced concrete tie beams to absorb the eccentric thrusts from the arches.

As a consequence of certain difficulties with the contractors, the foundations

Photo 1. — General view.

Photo 2. — General view : abutments and arches.

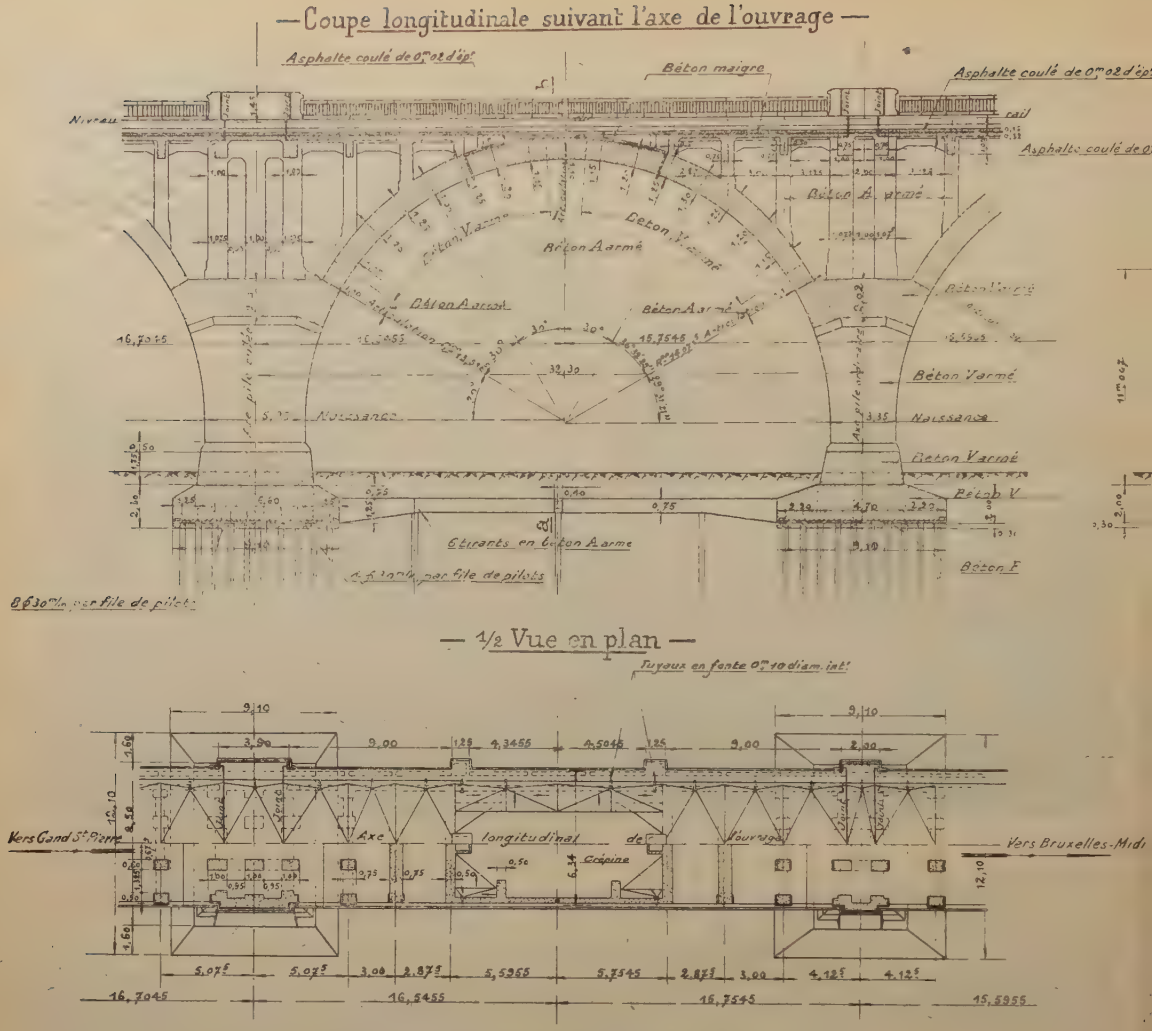
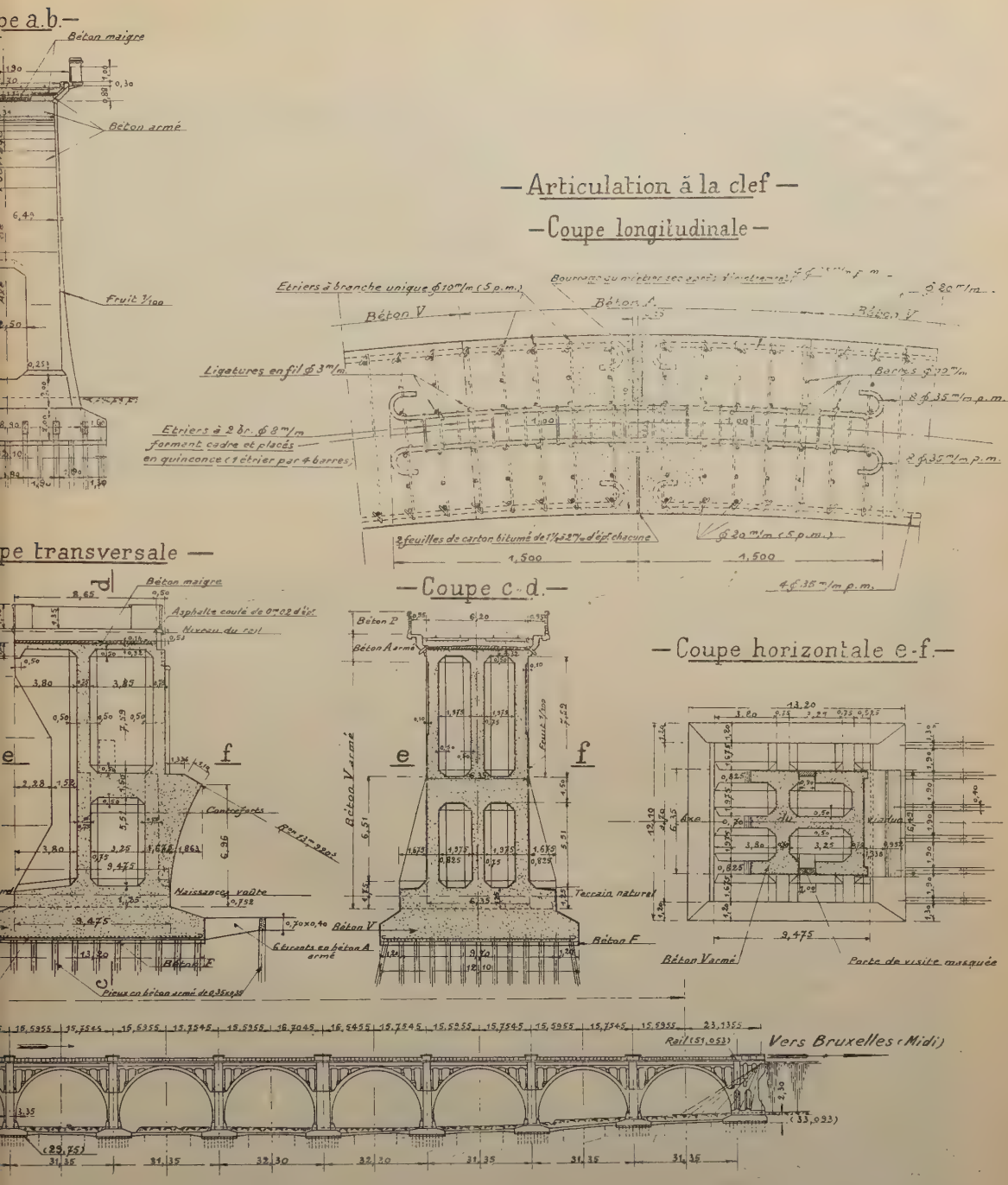


Fig. 1. — Brussels (Midi) to Ghent (St

Explanation o

Coupe longitudinale suivant l'axe de l'ouvrage = Longitudinal section along the centre line. — Niveau du rail = Rail level. — Béton maigre = Poor concrete. — Asphalte coulé de 0·m. 02 d'ép. = Asphalt 3/4 inch thick- — Béton A (V.) armé = Ferro-concrete A (V.). — Articulation = Hinge. — Naissance = Springing. — Ron = Radius. — 6 tirants en béton A armé = 6 tie beams in ferro-concrete A. — 4 (8) 30 mm. par file de pilots = 4 (8) (1 3/16 in.) dia. bars per row of piles. — Coupe *a b* = Section *a b*. — Axe de l'ouvrage = Centre line. — Niche = Refuge. — Articulation à la clef = Hinge at the crown. — Coupe longitudinale = Longitudinal section. — Echelle : 5 cm. p. m. = Scale 1/20. — Etriers à branche unique diam. 10 mm. (5 p. m.) = Single stirrups (3/8 inch) dia. (5 per metre). — Bourrage au mortier sec après décintrement = Rammed with dry mortar after removing the centres. — Ligatures en fil diam. 3 mm. = Binding wire (1/8 inch) dia. — Etriers à 2 br., diam. 8 mm. formant cadre et placés en quinconce (1 étrier par 4 barres) = Double stirrups (5/16 inch) dia., forming a frame and arranged in quinconx (1 stirrup for 4 bars). — 2 feuilles de carton bitumé de 1 1/2



ine. — The Pede viaduct (actually built).

ms in figure 1:

à 2 mm. d'ép. chacune = 2 sheets of bitumised cardboard each from 5/8 to 13/16 inch thick. — 1/2 vue en plan = Half plan view. — 1/2 coupe horizontale à divers niveaux = Half horizontal section at various levels. — Vers Gand St-Pierre = To Ghent (St. Pierre). — Vers Bruxelles-Midi = To Brussel (Midi). — Axe longitudinal de l'ouvrage = Longitudinal centre line. — Crépine = Weeper. — Tuyaux en fonte 0 m. 10 diam int. = Cast iron pipes 3 15/16 inches inside dia. — Coupe transversale = Cross section. — Culée vers Gand St-Pierre = Abutment towards Ghent (St. Pierre). — Ron = Radius. — Terrain naturel = Natural ground level. — Naissance voûte = Springing of the arch. — Contreforts = Counterforts. — 6 tirants en béton armé. A. — 6 tie-beams in ferro-concrete A. — Pieux en béton armé de 0.35 × 0.35 = Ferro-concrete piles 13 3/4 inches square. — Coupe horizontale e. f. = Horizontal section e. f. — Porte de vsite masquée = Concealed inspection door. — Axe du viaduc = Centre line of the viaduct. — Elévation générale = General elevation. — Pente de 0 m. 005 p. m. = Gradient 1 in 200.

were eventually built of piles cast in the ground, of the Simplex type. These piles therefore constitute the existing foundations of the Pede viaduct with the exception of two piers, where they were replaced by pre-cast ferro-concrete piles.

The contract was cancelled when the piling work was almost finished, the metal centering for the arches being then completely constructed.

From this time, profiting from experience and the changed state of the market, it was decided not to proceed with the execution of the former scheme, but to draw up a new one on other lines.

The foundations being constructed and the centres being ready at the site, it was necessary to adhere to the general outline of the former scheme. Nevertheless, in view of the inferior quality of the sub-soil, it was desirable to design the new arches according to the hinged principle so as to permit certain deformations without serious cracks developing. It was equally desirable to keep the weight of the structure as low as possible; with this object it was necessary to reduce its weight and its volume by using reinforced concrete and by lightening the members to a considerable extent. This programme was followed and new contracts let; the Pede viaduct, actually completed since several months, will be taken into service in the course of the year 1933 (photo No. 3).

General outline. — The structure is entirely in concrete and reinforced concrete. In accordance with the first scheme, the viaduct is composed of 4 groups of 4 semi-circular arches separated by bastion piers. The latter were provided essentially with the object of enabling the work to be carried out in successive groups, each consisting of 4 arches.

The spandrels above the arches are of open construction and form a secondary viaduct with ribbed slabs under the track resting upon small piers on plain transverse walls.

The track is laid upon ballast placed in the trough-shaped concrete floor (photo No. 4).

Piers. — The piers are founded upon a concrete raft on piles moulded in the ground, of the Simplex type. These rafts are connected by reinforced concrete beams constituting ties and struts (photo No. 5). The piers are constituted by two massive vertical pillars connected at their base by the foundation raft and under the springing of the arches by a heavy beam forming the skewback of the arches. Transversely, each pier is strengthened on both sides by a light counterfort of approximately parabolic profile formed by a line whose inclination increases progressively towards the base.

Abutments. — The viaduct is terminated by two cellular abutments in reinforced concrete with longitudinal wing walls. The main body of the abutment consists of a box having 4 compartments limited longitudinally and transversely by partition walls in reinforced concrete. These walls are armoured on both faces by octogonal systems of bars at rather wide intervals (4 bars per metre) (photo No. 6).

This device of partitioning had been used previously by the Belgian National Railway Company (S. N. C. F. B.), in the construction of the abutments of the steel viaduct at Horloz on the line from Fexhe to Kimpempois.

Arches. — As a consequence of the desire to reduce the weight of the struc-

Photo 3. — Arch-pier and bastion pier.

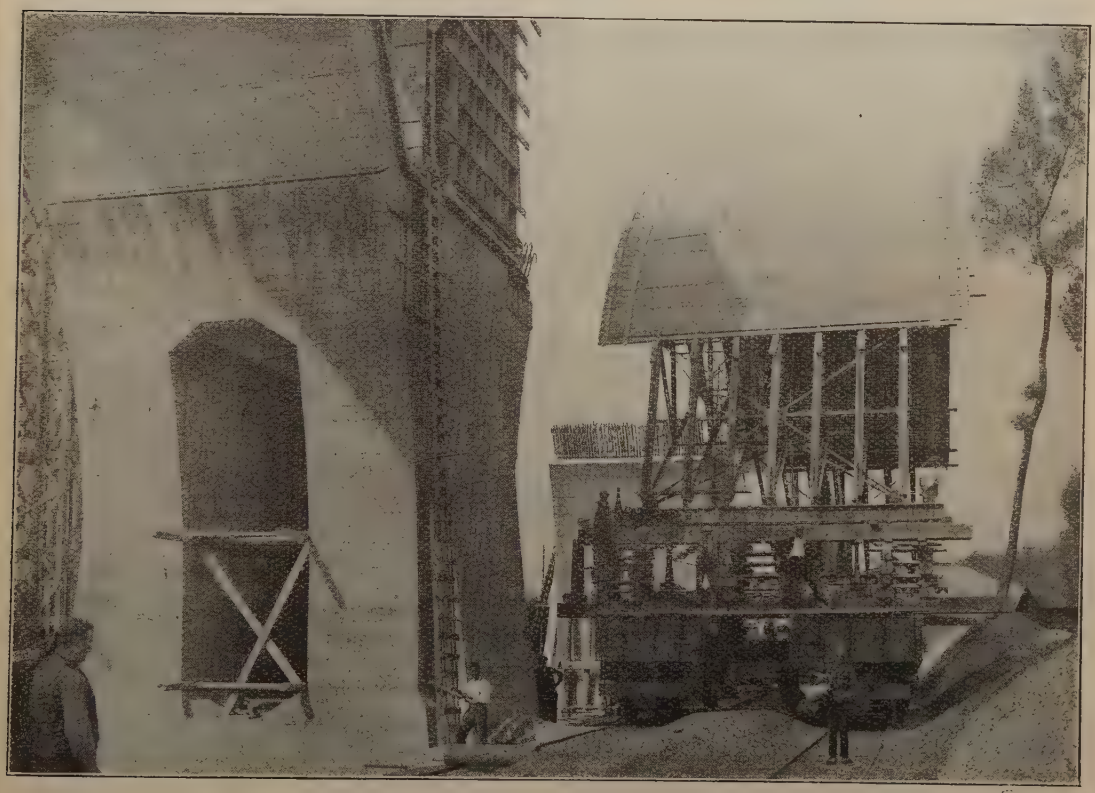


Photo 4. — Hollow pier. — Displacement of centre.

Photo 5. — Pede viaduct. — Concrete piers.

ture and at the same time to make it economically attractive, the widths of the arches and of the whole viaduct were reduced to the minimum compatible with a satisfactory support for the track (photo No. 7). The width of the arches was determined with the object of completely seating the track on the arch between the ends of the sleepers. No part of the track is therefore unsupported and laterally the superstructure is completed by light walls and cantilevered footways thus enclosing the ballast and completing the bedding of the track.

Hinges. — As already previously indicated the arches are of the « articulated » type. On account of the nature of the ground, it was necessary to provide for possible movement in the structure; hinged joints therefore became an essential feature of the construction. These joints are provided at the crown and at the theoretical springing points inclined at about 30° to the horizontal. We consider indeed — following the German practice — that it is more rational and more economical to limit the arches to the rupture joints rather than to extend them in costly materials in quite a useless manner so far as the horizontal springings (photo No. 8).

In the planning of the work it was

necessary from the first to discard any idea of simple contact hinges. Indeed it was a question of providing anchorages rather than true articulations. Following this line of reasoning, the advantage of a more or less perfect centering of the reactions could be sacrificed in return for a more solid connection between the parts of the arch. It was this consideration which caused preference to be given to a simple bonding by means of two rows of bars rather than

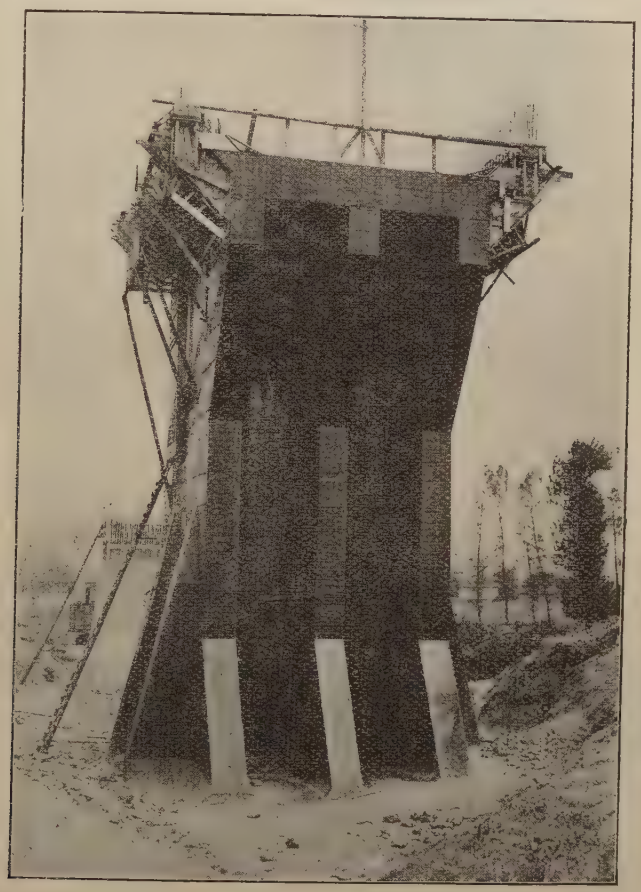


Photo 6. — Pede viaduct. — Abutment.

to the classical arrangement due to Mesnager. It is moreover sufficiently realised that the theoretical articulation is only one notion of the resistance of materials which is not realisable in practice (photo No. 9).

Each half arch in concrete is reinforced by an orthogonal network of bars at the extrados and the intrados (4 main bars of 35 mm. [1 3/8 inches] diameter per metre). Its thickness is 1.10 m. (3 ft. 7 5/16 in.) at the crown and at the

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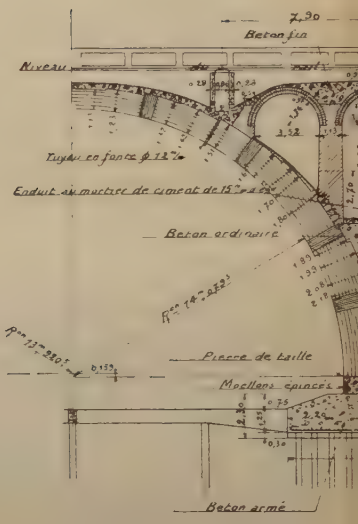

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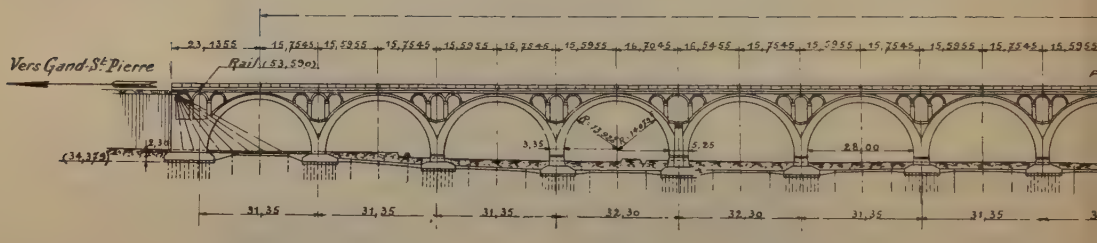


Fig. 11. — Brussels (Midi) to Ghent (St. Pierre

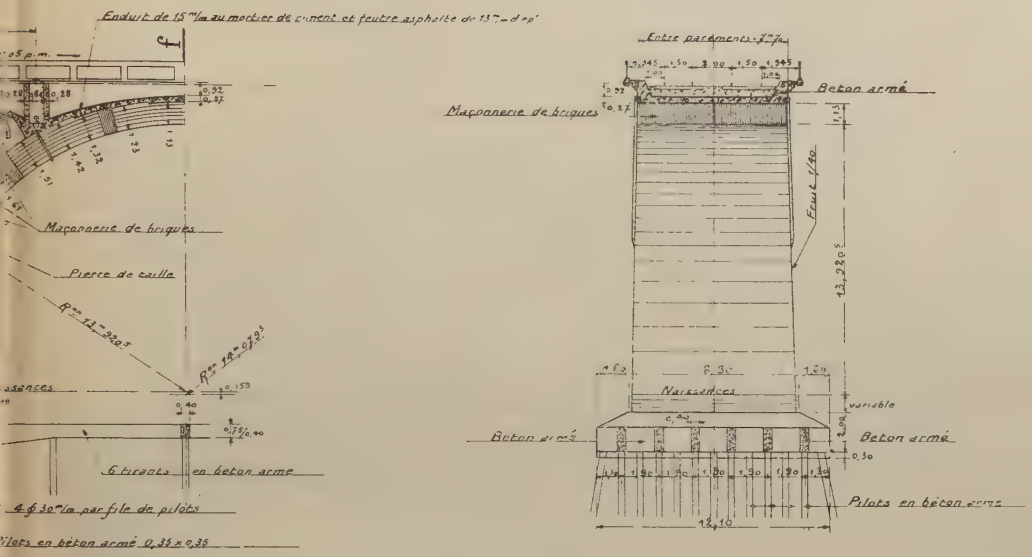
Expla

Béton fin = Fine concrete. — Enduit de 15 mm. au mortier, etc... = Plastering in cement mortar, 5/8 inch thick, and bitumised felt 1/2 inch thick. — Pente de 0 m. 005 = Gradient 1 in 200. — Tuyau en fonte diam. 12 mm. = 1/2-inch cast iron pipe. — Maçonnerie de briques = Brickwork. — Béton ordi-

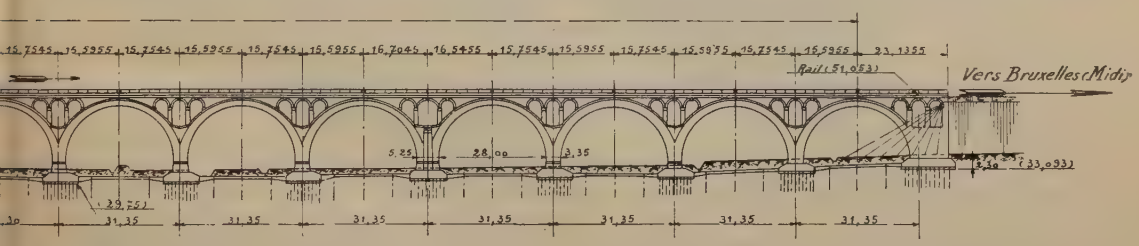
springings, it is gently swollen to 1.30 m. (4 ft. 3 5/32 in.) towards the haunches. The articulations are incorporated in half voussoirs of 1 m. (3 ft. 3 3/8 in.) depth at the crown and springings.

The hinge reinforcement is arranged in two parallel layers of 8 bars per metre, which are symmetrical about the centre and placed at intervals of 20 cm. (7 7/8 in.). The diameters are 35 mm.

Section e-f.


Enduit de 15 m/m au mortier de ciment et feutre asphalte de 13 m/m d'ép.
Maçonnerie de briques
Pierre de taille
6 tirants en béton armé
4 ϕ 30 m/m par file de pilots
Pilots en béton armé 0,35 x 0,35
Entre parements
Béton armé
Maçonnerie de briques
Naissances
Béton armé
Béton armé
Pilots en béton armé

énérale —



ıct. Design of brickwork structure (not carried out).

ch terms:

naire = Ordinary concrete. — Pierre de taille = Dressed ashlar. — Moellons épincés = Tapered ashlar. — Naissances = Springings. — Béton armé = Reinforced concrete. — Pilots en béton armé de 0.35 × 0.35 = 13 3/4 in. × 13 3/4 in. reinforced concrete piles.

(1 3/8 inches) at the crown and 38 mm. (1 1/2 inches) at the springings.

In order to ensure maximum strength the sections containing the hinge reinforcement have been made capable of carrying completely the thrust due to the reactions.

Construction of the arches. — The arches were constructed in separate sections and keyed together (photo No. 10).

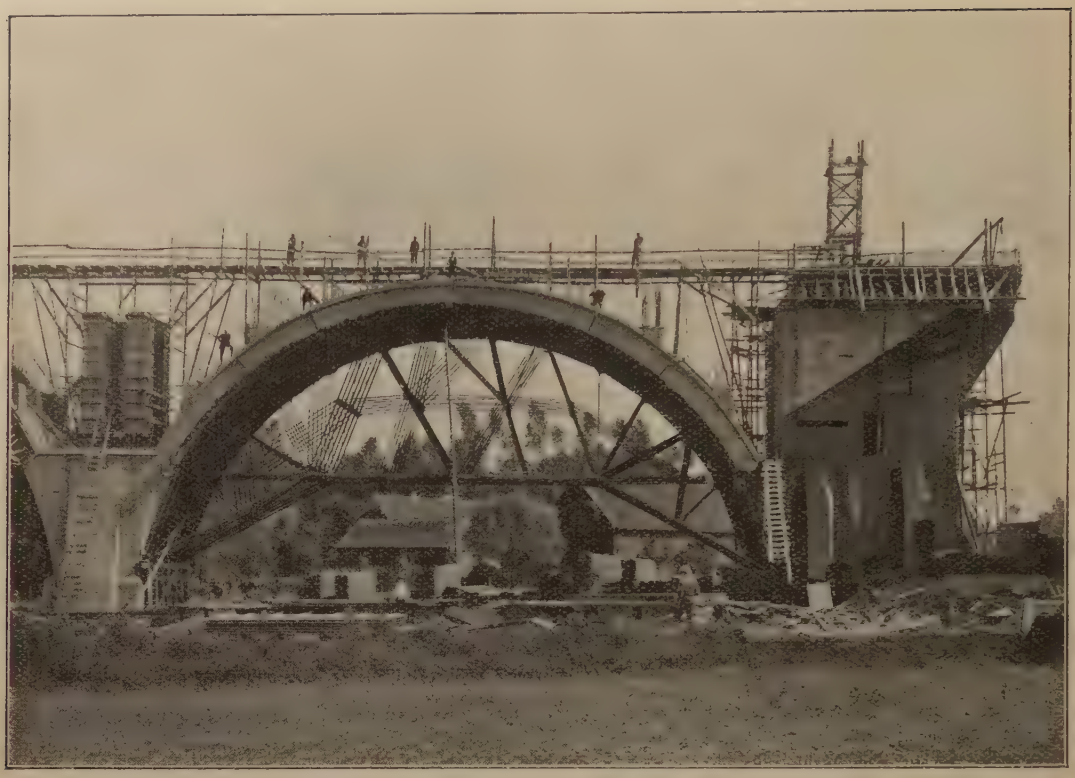


Photo 7. — Pede viaduct. — Arch and abutment.

They were moulded on wood laggings supported upon metal centres. The set of centres for 4 arches served for the successive construction of the 4 series of arches.

The reinforcement, including the main bars (without joints) having been all set in position, the concreting was started at the hinge voussoirs of the springings and the crown. Each of the remaining half arches was then divided into 3 voussoirs separated by keyed joints. These voussoirs numbered 1, 2, 3 starting from the springing were concreted in the order 1, 3, 2. After sufficient hardening had taken place the two empty joints remaining between 1 and 3 and between 3 and 2 were bonded with dry mortar (photo No. 11).

This programme was followed completely and has ensured a perfect execution of the work.

If, when a series of arches having been concreted and having hardened sufficiently, the centres were to be removed and re-erected in position for the next series, the dismantling and re-erection of light centres would have been difficult and tedious; it was preferred to transport them as a single unit on wagons upon a temporary railway, the haulage being done by cables (photo No. 12).

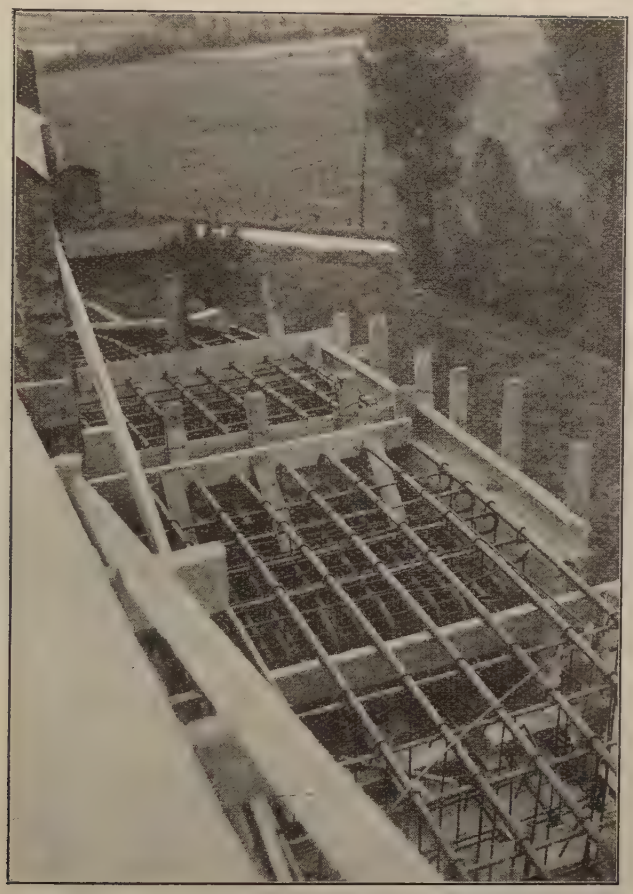


Photo 8. — Pede viaduct. — Reinforcement of an articulated crown joint.

The removal and replacement in position of the centres were performed without any mishap.

Superstructure. — After the removal of the centering from the arches, the next step was the construction of the superstructure (photo No. 13).

The tracks in ballast rest in a trough which projects laterally on both sides from the supporting arched vaults. This trough is formed by ferro-concrete slabs which are ribbed where they support the track and which carry the brackets on each side. It rests upon isolated columns or upon transverse walls without hinges, which spring from and carry the loads to the arches. These supports are reinforced.

Parapets. — The structure is completed by a metal parapet simpliy intercepted by refuges in ferro-concrete situated immediately above the piers.

Photo 9. — Reinforcement of an arch on centre.

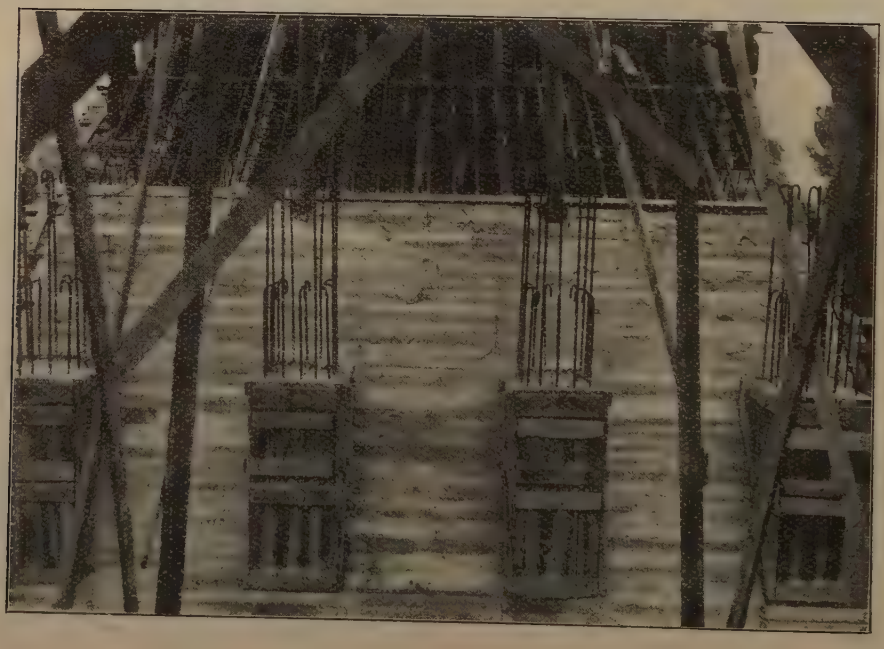


Photo 10. — Springing of piers. Arch being concreted.

Drainage. — The base slab of the ferro-concrete decking trough is protected against the infiltration of water and against possible damage resulting from the maintenance processes of the permanent way by a double coating of cement mortar covered by a layer of bituminous mastic of 2-cm. (3/4-inch) thickness protected in its turn by a covering of weak concrete of 4 to 5 cm.

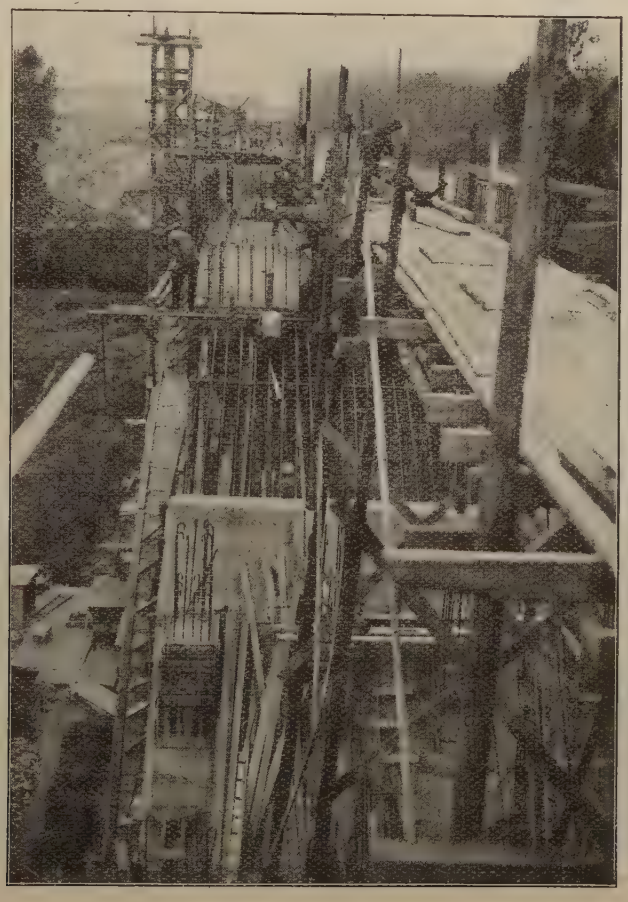


Photo 11. — Pede viaduct. — View during construction.

(1 9/16 to 1 31/32 inches) thickness, with smoothed surface.

In addition the trough is plentifully furnished with weepers for the dispersion of water.

Composition of the concrete. — Broken granite of variyng gauges and Brussels Sart-Moulins sand were used exclusively in the manufacture of the concrete.

As a result of a number of tests of strength and efficiency, the proportions of the concrete for the arches were fixed as follows :

250 kgr. (*550 lb.*) of cement,
300 l. (*0.39 c. yard*) of sand,
300 l. (*0.39 c. yard*) of gravel (5/64 to 3/16 inch),
100 l. (*0.13 c. yard*) of gravel (3/16 to 3/4 inch),
800 l. (*1.04 c. yard*) broken stone (3/8 to 2 inches).

This composition agrees closely with the standard proportioning of the Fuller Bolomey curve and has ensured an exceptionally compact mixture. This mixture was adopted for the construction of the piers and abutments as well as for the arches.

Photo 12. — Pede viaduct. — Displacement of centre.

The superstructure and the hinge blocks were carried out in reinforced concrete of the usual proportions :

350 kgr. (770 lb.) of cement,
400 l. (0.52 c. yard) of sand,
800 l. (1.04 c. yard) of gravel (3/16 to 3/4 inch).

The fine concrete for sealing the key stones had the following composition :

500 kgr. (1 100 lb.) of cement,
350 l. (0.46 c. yard) of sand,

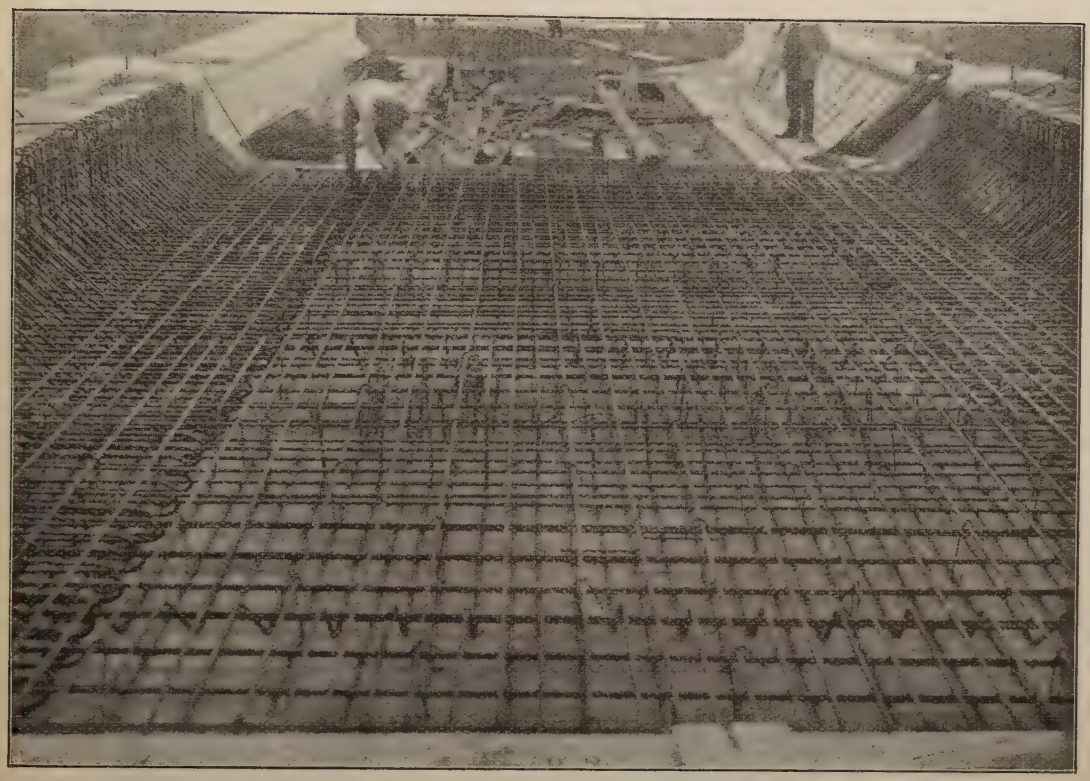


Photo 13. — Pede viaduct. — Reinforcement of trough-shaped flooring.

700 l. (0.91 c. yard) of gravel (5/64 to 3/16 inch).

Tests were made with the Abram's cone which gave no positive results due to the use in the work of concrete containing only a small amount of water.

Compression tests on cubes of 20 cm. (7 7/8 inches) were performed at regular intervals. The results of these vary appreciably.

The Pede viaduct is constructed to carry the heaviest conventional train loading of the S. N. C. F. B., the weight of the driving axles being 25 tons. A considerable margin of safety has therefore been provided for the future.

The drawings for this work have been prepared entirely by the engineering staff of the S. N. C. F. B.

The works have been carried out in a faultless manner by the contracting firm of Charels & Abras, under the direction of Mr. Abras.

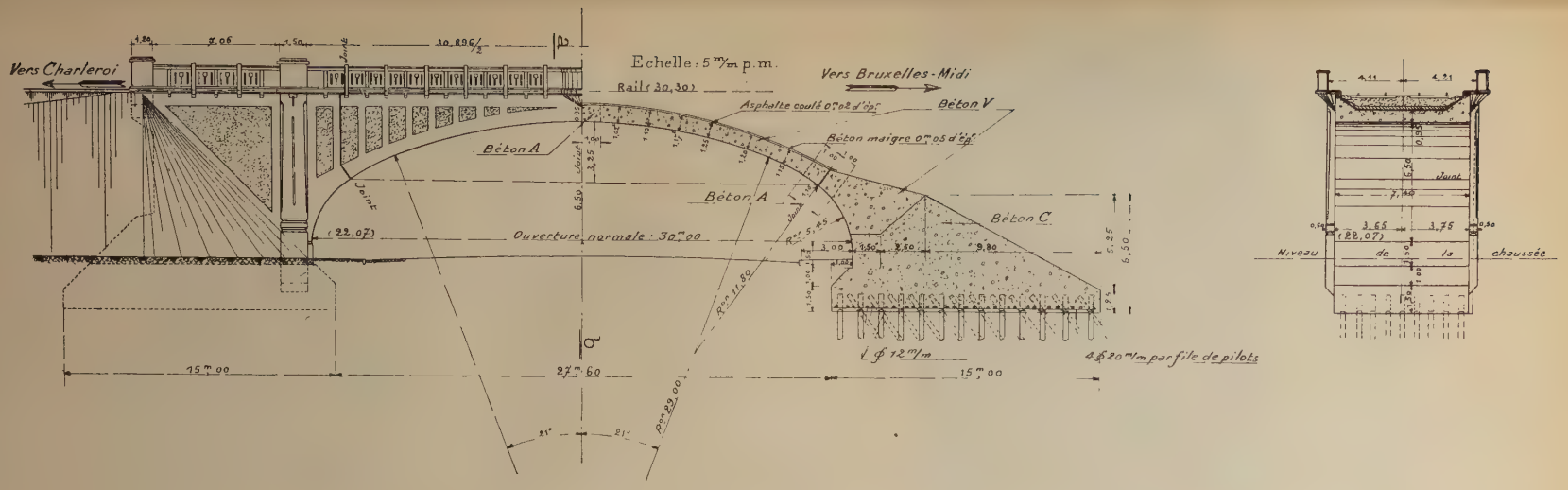
Line from Brussels (Midi) to Charleroi.

The Luttre Bridge at Forest.

The bridge known as the Luttre bridge on the line from Brussels to Charleroi, near the exit from Brussels (Midi) station, at Forest, has been entirely reconstructed in concrete in connection

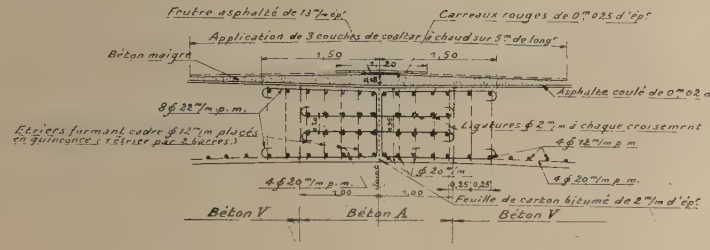
Photo 14. — « Luttre » bridge at Forest.

Photo 14*bis*. — « Luttre » bridge at Forest.



Details of arch joints.

At the arch key.


Feutre asphalté de 13 m/m ép.
Carreaux rouges de 0m025 d'ép.
Application de 3 couches de coaltar à chaud sur 5m de long
Béton maigre
Asphalte coulé de 0m02 d'ép.
8 ϕ 22 m/m p.m.
Etriers formant cadre ϕ 12 m/m placés en quinconce (1 étrier par 2 barres)
Ligatures ϕ 2 m/m à chaque croisement
4 ϕ 12 m/m p.m.
4 ϕ 20 m/m p.m.
Feuille de carton bitumé de 2 m/m d'ép.
Béton V
Béton A
Béton V

At the springings.

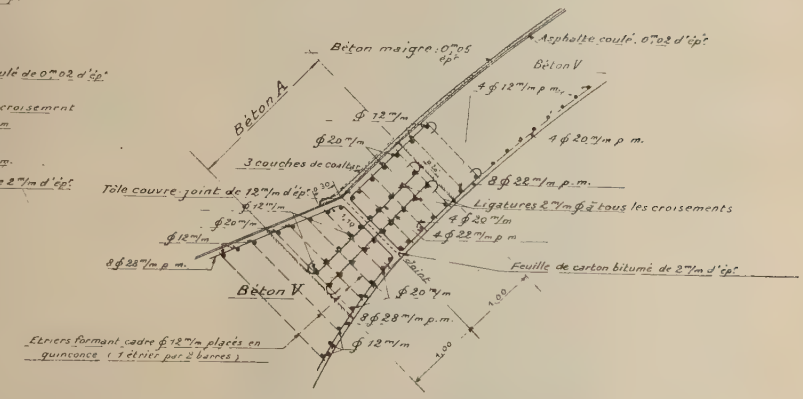

Béton maigre 0m05 ép.
Asphalte coulé 0m02 d'ép.
Béton V
Béton A
4 ϕ 12 m/m p.m.
ϕ 12 m/m
ϕ 20 m/m
1 ϕ 20 m/m p.m.
3 couches de coaltar
8 ϕ 22 m/m p.m.
Tôle couvre-joint de 12 m/m d'ép.
Ligatures 2 m/m ϕ à tous les croisements
4 ϕ 20 m/m
4 ϕ 22 m/m p.m.
Feuille de carton bitumé de 2 m/m d'ép.
Béton V
Etriers formant cadre ϕ 12 m/m placés en quinconce (1 étrier par 2 barres)

Fig. 111. — Charleroi to Brussels (Midi) line. « Luttre » bridge.

Explanation of French terms:

Vers Charleroi = To Charleroi. — Vers Bruxelles-Midi = To Brussel (Midi). — Échelles : 5 mm. p. m. = Scale : 1/200. — Béton A (C, V) = Concrete A (C or V). — Ouverture normale = Normal span. — Asphalte coulé 0 m. 02 d'ép. = Asphalt (3/4 inch) thick. — Béton maigre 0 m. 05 d'ép. = Poor concrete 2 inches thick. — Par file de pilots = Per row of piles. — Ron = Radius. — Niveau de la chaussée = Road level. — Feutre asphalté de 13 mm. ép. = Bitumised felt, 1/2 inch thick. — Carreaux rouges de 0 m. 025 d'ép. = Red tiles 1 inch thick. — Application de 3 couches de coaltar à chaud sur 5 m. de long = Treated with 3 coats of hot coaltar on a length of 16 1/2 feet. — Feuille de carton bitumé de 2 mm. d'ép. = Sheet of bitumised cardboard 5/64 inch thick. — Ligatures diam. 2 mm. à chaque croisement = Binding wire of 5/64 inch dia. at each intersection. — Etriers formant cadre, diam. 12 mm. placés en quinconce (1 étrier par 2 barres) = Stirrups 1/2 inch dia., arranged in quinconx forming a frame (1 stirrup per 2 bars). — Tôle couvre-joint de 12 mm. d'ép. = Plate (1/2 inch) thick covering joint. — Ligatures 2 mm. diam. à tous les croisements = Binding wire of 5/64 inch dia. at each intersection. — 3 couches de coaltar = 3 coats of coal tar.

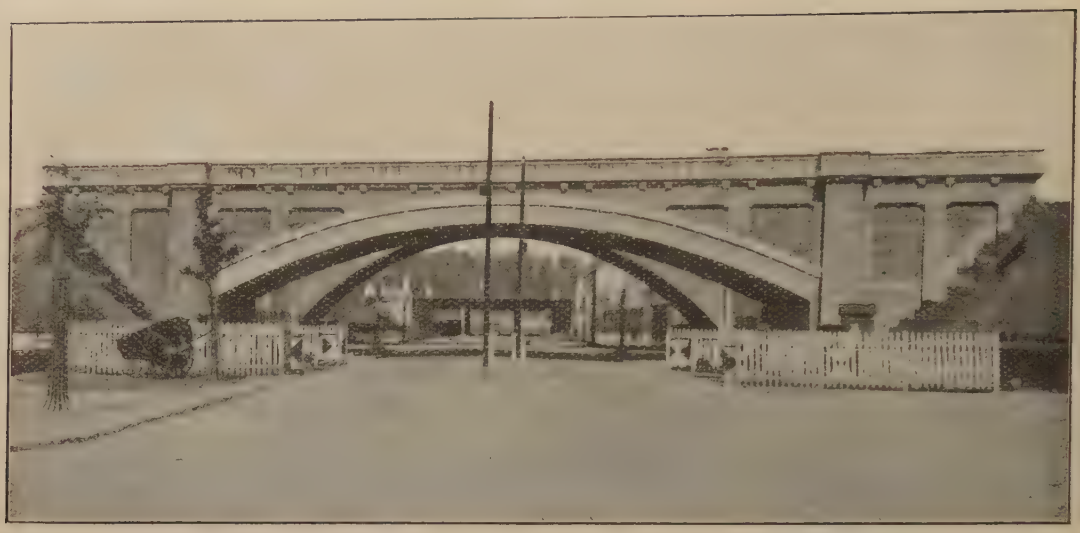


Photo 15. — Brussels (Midi) to Mons line. « Rue du Charroi » bridge, at Forest.

with the new layout of tracks at the Brussels (Midi) station (photos Nos. 14 and 14*b*).

It is constituted by a concrete arch having 3 anchor-hinges of the type used at the Pede viaduct springing from 2 concrete abutments founded on timber piles.

The clear span between abutment walls is 30 m. (98 1/2 feet) and the profile of the intrados is that of an elliptic arch depressed 1/4.

The thickness of the arch is 0 m. 95 (3 ft. 3 1/8 in.) at the crown and 1 m. 10 (3 ft. 7 5/16 in.) at the springings. It is limited to the assumed joints of rupture at half the maximum height of the intrados. It is provided with hinges in layers of parallel bars similar to those of the Pede viaduct and it is reinforced with a broad network of bars at the intrados. The joints at the crown and springings remain visible in the elevation.

The outline of the abutments has been designed with the object of giving the skewback blocks a gradual swelling extending as far as the foundations.

The wing walls have been mutually tied and strutted by ferro-concrete beams anchored in the walls.

The ingredients of the concrete of crushed stone are as follows :

Concrete V (arch) :

250 kgr. (550 lb.) of cement,
400 l. (0.52 c. yard) of sand (Mont-St.-Guibert or similar),
800 l. (1.04 c. yards) of crushed stone (3/8 inch to 2 inches).

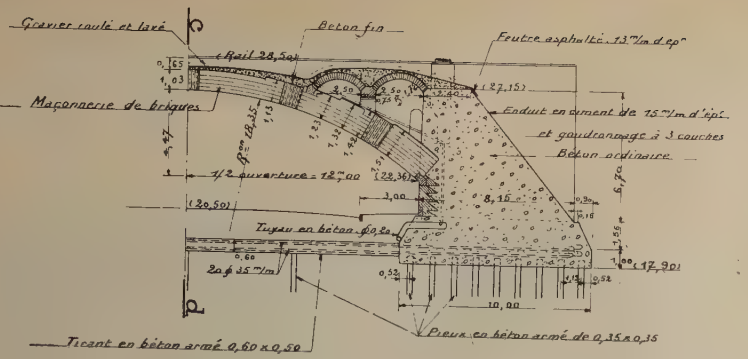
Concrete F (foundations) :

175 kgr. (385 lb.) of cement,
400 l. (0.52 c. yard) of sand,
800 l. (1.04 c. yards) of crushed stone (3/8 inch to 2 inches).

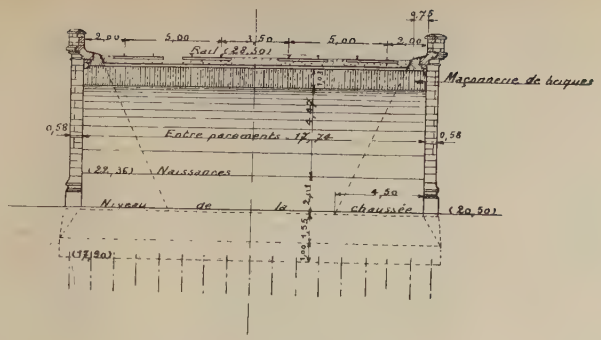
Concrete C (abutments) :

200 kgr. (440 lb.) of cement,
400 l. (0.52 c. yard) of sand,
800 l. (1.04 c. yards) of crushed stone (3/8 inch to 2 inches).

Half cross section.

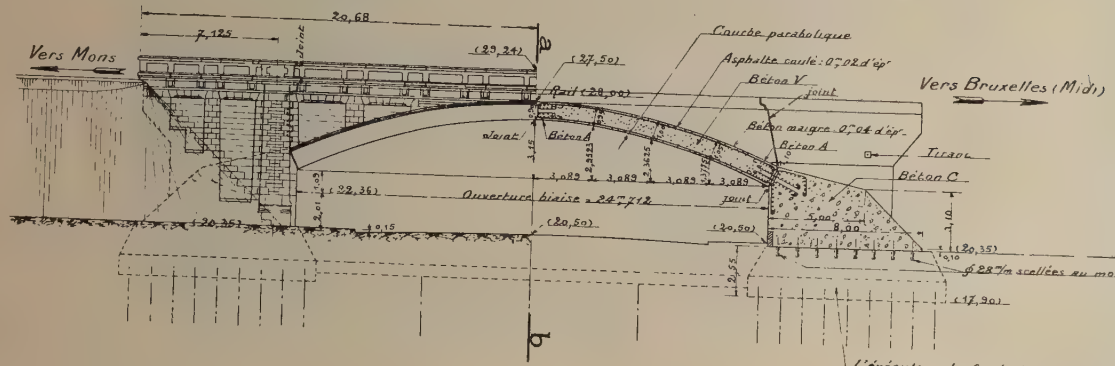

Gravier roulé et lavé
Béton fin
Feutre asphalté 13 m/m d'ép.
Rail 28,500
Maçonnerie de briques
Enduit en ciment de 15 m/m d'ép.
et goudronnage à 3 couches
Béton ordinaire
1/2 ouverture = 12,00
Tuyau en béton Ø 0,20
Tirant en béton armé 0,60 x 0,50
Pieux en béton armé de 0,35 x 0,35

Section c-d.



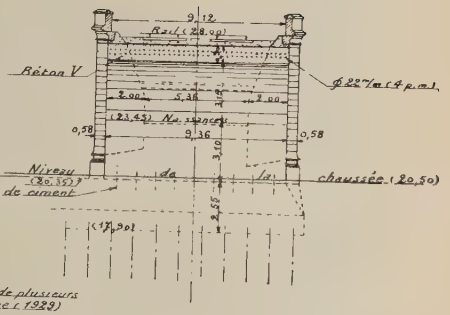
II. — Structure actually built.

Half elevation.



Half oblique cross section.

Section a-b.



L'exécution des fondations est antérieure de plusieurs années (1913) à l'achèvement de l'ouvrage (1929)

Fig. IV. — Brussels (Midi) to Mons line. Underline bridge of 24 m. (78 ft. 9 in.) span for the « Rue du Charroi ».

Explanation of French terms:

Gravier roulé et lavé = Rolled and washed gravel. — Béton fin = Fine concrete. — Feutre asphalté 13 mm. ép. = Bitumised felt 1/2 inch thick. — Maçonnerie de briques = Brickwork. — 1/2 ouverture, 12 m. = Half span, 39 ft. 4 1/2 in. — Tuyau en béton, diam. 0.20 = Concrete pipe, 7 7/8 in. dia. — Tirant en béton armé, 0.60 × 0.50 = Ferro-concrete tie, 23 5/8 × 19 11/16 in. — Enduit en ciment de 15 mm. ép. et goudronnage à 3 couches = Plastering in cement 5/8 inch thick and 3 coats of tar. — Béton ordinaire = Ordinary concrete. — Pieux en béton armé de 0.35 × 0.35 = Ferro-concrete piles 13 3/4 in. × 13 3/4 in. square. — Maçonnerie de briques = Brickwork. — Entre parements, 17.74 = Between faces, 58 ft. 2 in. — Naissances = Springings. — Niveau de la chaussée = Road level. — Courbe parabolique = Parabolic curve. — Asphalte coulé 0 m. 02 d'ép. = Asphalt (3/4 inch) thick. — Béton maigre = Poor concrete. — Tirant = Tie. — Ouverture biaise, 24.712 = Skew span, 81 feet. — L'exécution des fondations est antérieure de plusieurs années (1913) à l'achèvement de l'ouvrage (1929) = The foundations were constructed in 1913, several years before the completion of the work (1929). — Diam. 28 mm. scellées au mortier de ciment = Bars 1 1/8 inch dia. sealed in cement mortar.

Concrete C (reinforced) :

300 or 350 kgr. (660 or 770 lb.) of cement,
400 l. (0.52 c. yard) of sand,
800 l. (1.04 c. yards) of crushed stone 3/16 to 13/16 inches).

Concrete P (parapets) :

350 kgr. (770 lb.) of cement,
400 l. (0.52 c. yard) of sand,
800 l. (1.04 c. yards) of gravel (5/64 to 3/16 inch).

The crushed stone may be replaced by gravel provided that the final percentage of cement is the same (fig. III).

The Rue du Charroi bridge at Forest.

The Rue du Charroi bridge at Forest, on the line from Brussels to Mons, is a structure in concrete with the vault lightly armoured (photo No. 15).

This bridge has a clear span of 26-m. (85 ft. 3 in.) between abutment walls, the vault having a semi-circular intrados in order to harmonise with the nearby bridge of the same span under the line from Brussels (Midi) to Ghent (St-Pierre).

This work had originally been intended to be in brickwork, the foundations and tie beams having been previously constructed. The design of the new work was thus limited to the elevation.

The abutments are in concrete, the arch is in concrete lightly reinforced with two systems of bars at right angles in the intrados with three anchor-hinges of the Pede type.

The parapets are constructed in ashlar of blue stone and sandstone detailed to accord with the neighbouring bridge under the line from Brussels (Midi) to Ghent (St.-Pierre).

The concrete proportions are the same as those for the Luttre bridge.

We supply, as a matter of interest, some views and sections of the bridge as originally designed in brickwork and of the bridge as actually constructed in concrete (fig. IV).

Over-line bridges in concrete.

In the construction of new railways during recent years, there has been used, in certain cases, in deep cuttings through firm ground, a type of over-line road bridge characterised by a concrete arch on mass concrete foundations with lightened haunches and abutments.

The hingeless arch has a little reinforcement at the springings and the crown to resist temperature and shrinkage stresses. The haunches and abutments are lightened by secondary semi-circular arches on thin piers. This type of work has been constructed namely on the line from Schaerbeek to Hal at Beersel and at Tourneppe, on the cutting situated on the loop from Braine-le-Comte to Hennuyères and likewise under the Tournai road across the Hal-Brages branch (photo 16 and fig. V).

Line from Brussels (Midi) to Ghent (St.-Pierre).

Structures on the Molenbeek and the Cauterbroeckbeek.

We can cite as affording a certain interest, not as regards the span but the mode of construction, two structures built on the new line from Brussels (Midi) to Denderleeuw over the Molenbeek and the Cauterbroeckbeek.

These works are short viaducts of three arches on high, slender and lightened piers and abutments supporting non-reinforced concrete vaults.

The piers are founded on piles, the foundation rafts being connected in the

Photo 16. — Schaerbeek to Hal line. Over-bridge at Beersel.

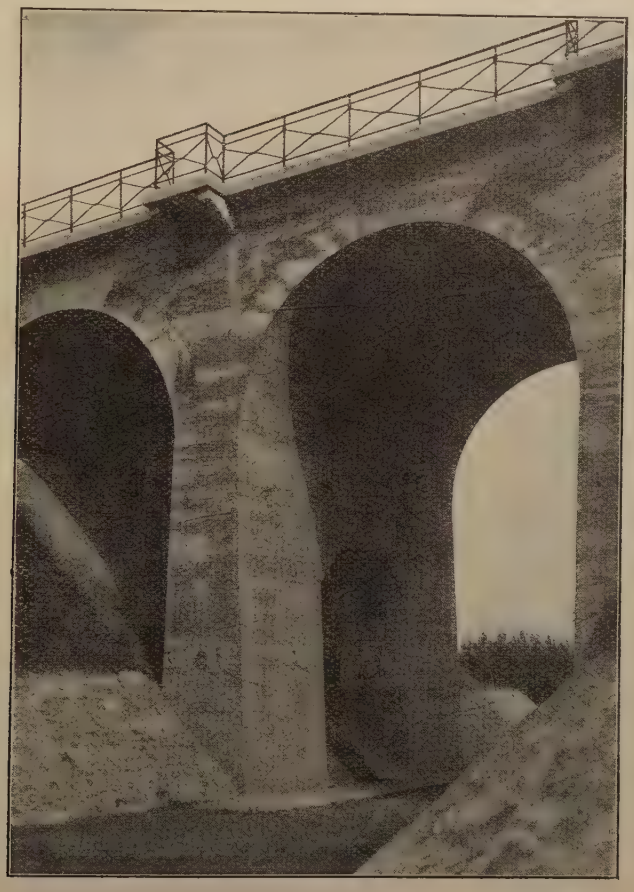


Photo 17. — Bruxelles (Midi) to Ghent (St. Pierre) line. Viaduct over the Molenbeek.

Half elevation. Half longitudinal section. Cross section.

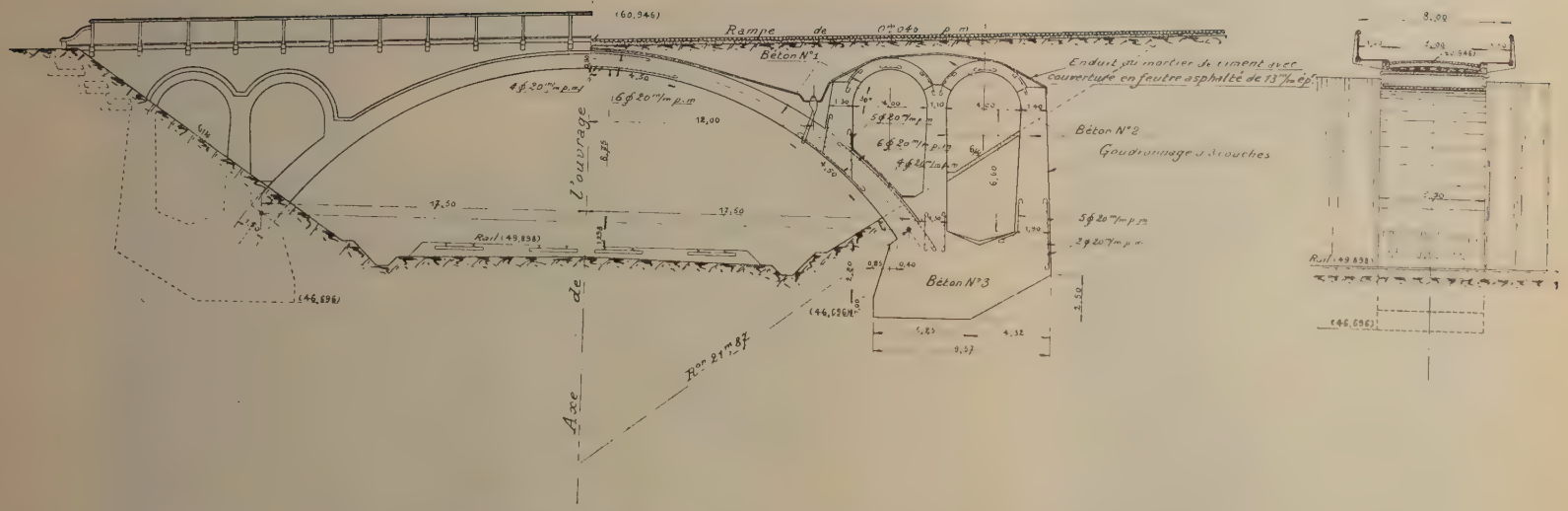
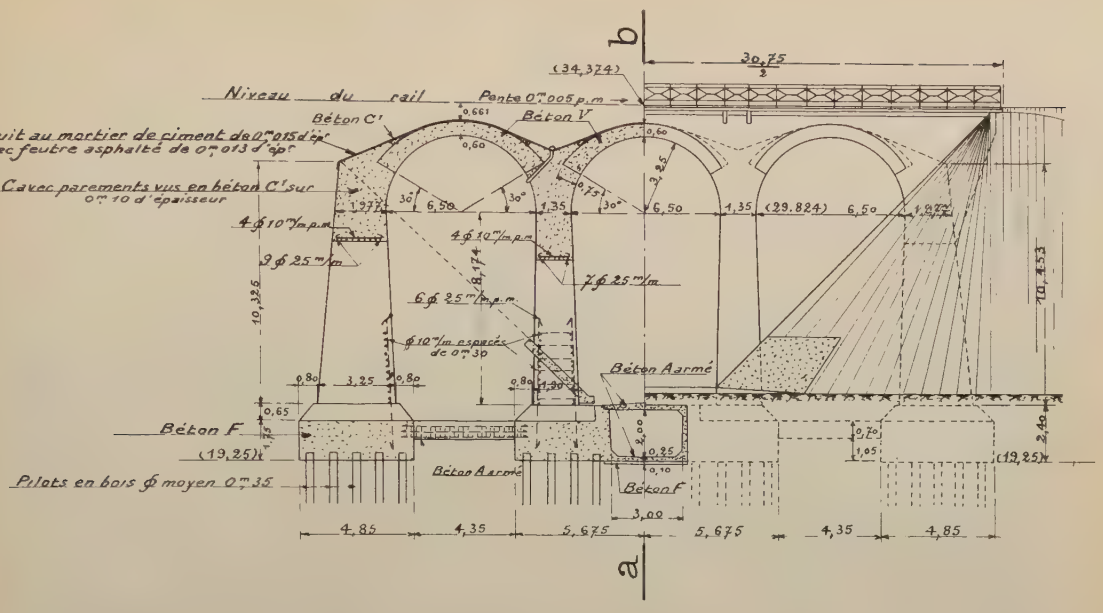


Fig. V. — Schaerbeek to Hal line. Bridge under the « Chemin du Cimetière » at Tourneppe.

Explanation of French terms:

Rampe de 0 m. 046 p. m. = Gradient 1 in 21.7. — Béton N° 1 (N° 2) = Concrete N° 1 (N° 2). — Axe de l'ouvrage = Centre line of structure. — Enduit au mortier de ciment avec couverture en feutre asphalté de 13 mm. ép. = Cement plastering with a layer of bitumised felt, 1/2 inch thick. — Goudronnage à 3 couches = 3 coats of coaltar. — R^{or}, 21.87 = Radius, 71 ft. 9 in.

Longitudinal section.



Section *a-b*.

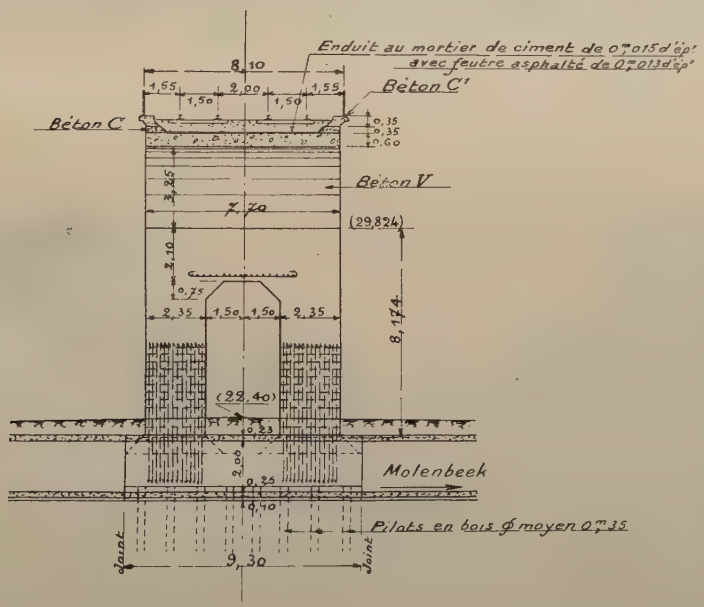


Fig. VI. — Brussels (Midi) to Ghent (St. Pierre) line. Underline bridge built for the diversion of field path No. 11 and the Molenbeek stream, at Wambeek.

Explanation of French terms:

Niveau du rail = Rail level. — Pente 0 m. 005 p. m. = Gradient of 1 in 200. — Enduit au mortier de ciment, etc. = Cement mortar plastering, 5/8 inch thick with bitumised felt 1/2 inch thick. — Béton C avec parements... = Concrete C with facings in C[1] concrete 3 15/16 inches thick. — 4 (6, 9...) diam. 10... mm. = 4 (6, 9...) bars, 3/8... inch dia. per metre. — Pilots en bois, diam. moyen 0 m 35 = Timber piles, average dia. 13 3/4 inches.

Photo 18. — Hooge Bistbaan bridge at Eeckeren (Antwerp).

Photo 19. — Driehoekstraat bridge at Eeckeren (Antwerp).

middle by a frame serving as a channel for the stream and laterally by ferro-concrete tie beams.

The wing walls are of minimum length.

These structures are light and economical (photo 17 and fig. VI).

Under-line bridges in concrete.

In the planning of new railways, it is necessary to provide in many cases for the construction of bridges to enable roads to cross under the line, and in which the difference of level between the rails and the road is small enough. Whenever possible, the railway company always gives preference to an arched structure in masonry rather than to a steel girder bridge.

The principal reasons for this choice are greater margin of strength for future developments and a diminished maintenance in favour of the arched masonry bridge.

In recent years, it has been decided to use concrete on a large scale in the execution of these works. Concrete arches are generally not reinforced, except in the case of skew spans when the upper parts only are reinforced (photo 18).

The small structures are hingeless. Spans of approximately 12 to 15 m. (39 1/2 to 49 feet) and above with foundations in soft ground of a compressible nature have articulated arches. The articulations are obtained simply by a cut surface at the joint in which a sheet of bituminous cardboard is inserted; a number of centralised bars pass through the joint to serve as anchorages and eventually to carry the shearing load. The springings always coincide with the joints of rupture. The abutments are carried up to the inclined springings, the arch when freed taking its bearing upon its skewbacks. This method produces an economy in material and in centres (fig. VII).

The abutments are designed so as to constitute the logical swelling out of the arch into its foundations. In some cases the supports have been lightened by means of a cellular construction. The shape of the intrados of the arch is generally elliptical with depressions of 1/3 or 1/4.

We give in conjuction with this paper a series of sections of bridges having various spans indicating clearly enough the method of construction (fig. VIII).

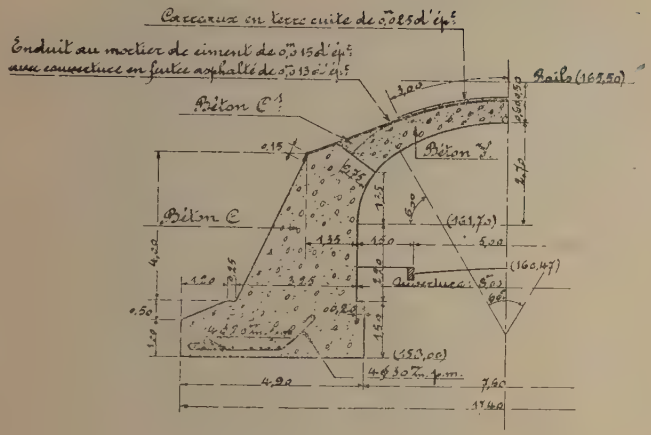
We also give the section of an under-line bridge built on the new line from Fexhe to Kinkempois and Ougrée. This bridge has a backed arch to reduce the thrust from the high embankment; in addition to prevent cracks which would be harmful to the distribution of the load, the arches are cut at the springings and the crown and the whole body of the tunnel is itself cut transversally at intervals in order to reduce the effect of possible irregular settling.

In the case of foundations in compressible ground, the cuts at the joints of the arch are justified by the necessity for preventing the formation of accidental cracks when the structure is put under load.

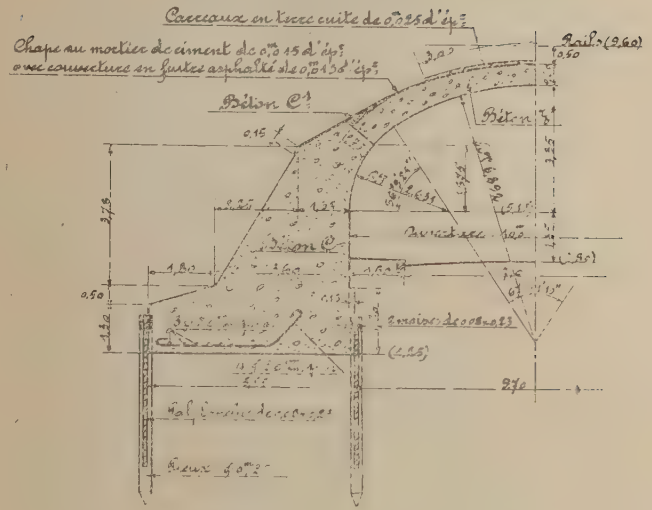
The bridge is built fully exposed without any earth load whatever; in this state, it behaves perfectly without showing the least trace of cracks.

The most severe test occurs during the execution of the earth fill behind the abutments. The bridge may be constructed with dimensions adequate to resist on the one hand the thrusts from the arch and on the other the earth pressures. During the process of execution of the embankment the adjacent ground is loaded. As it is compressible it shrinks vertically and swells laterally ac-

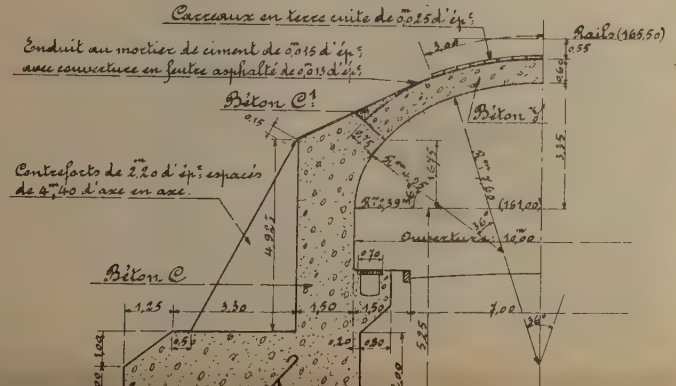
a) Span: 8 m. (26 ft. 3 in.).



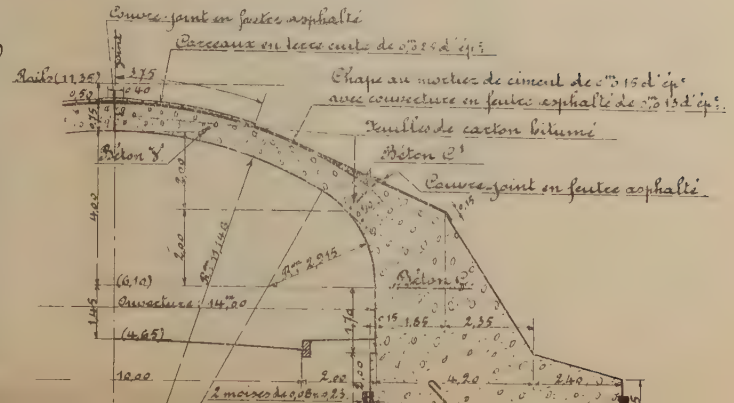
b) Span: 10 m. (32 ft. 9 in.).



c) Span: 10 m. (32 ft. 9 in.)
(with counterfort).



d) Span: 14 m. (45 ft. 11 in.).



e) **Span: 15 m. (49 ft. 2 in.).**

f) **Span: 18 m. (59 feet).**

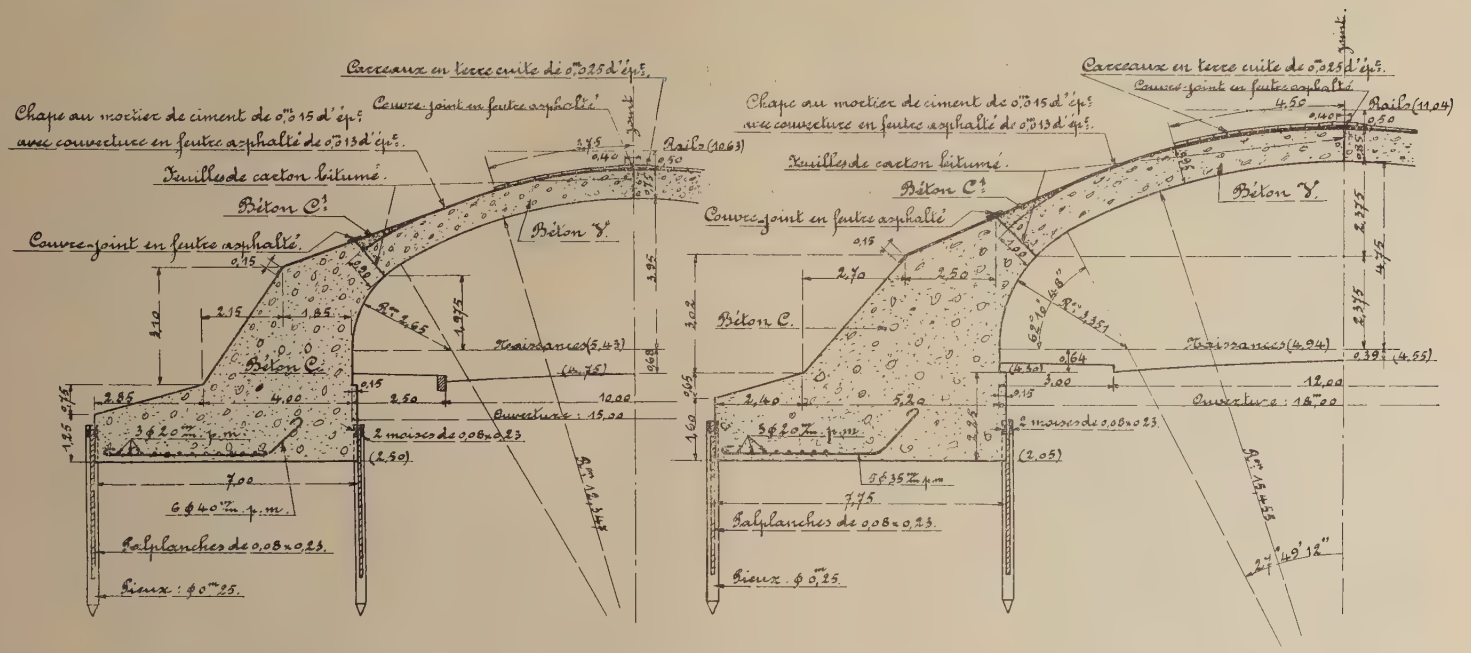
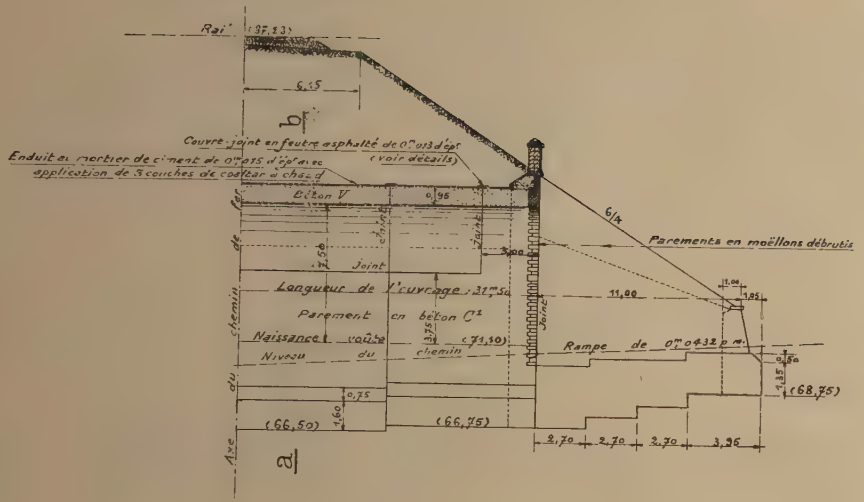


Fig. VII. — Types of underline bridges with concrete arch. — Cross sections.

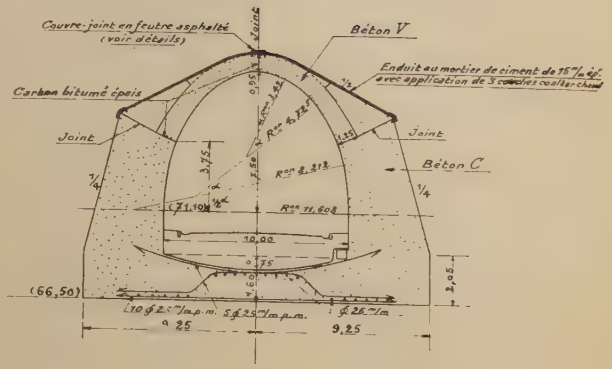
Explanation of French terms:

Carreaux en terre cuite de 0 m. 025 d'ép. = Earthenware tiles 1 inch thick. — Enduit (chape) au mortier de ciment de 0 m. 015 d'ép., avec couverture en feutre asphalté de 0 m. 013 d'ép. = Plastering in cement mortar 5/8 inch thick with covering of bitumised felt 1/2 inch thick. — Ouverture = Span. — R^m = Radius. — 2 moises de 0.08 × 0.23 = 2 twins, 3 1/8 in. × 9 1/16 in. — Palplanches de 0.08 × 0.23 = Sheet piling, 3 1/8 in. × 9 1/16 in. — Pieux, diam. 0 m. 025 = Piles, 9 7/8 in. dia. — Contreforts de 2 m. 20 d'ép., espacés de 4 m. 40 d'axe en axe = Counterforts 7 ft. 3 in. thick spaced at 14 ft. 6 in. centres. — Couvre-joint en feutre asphalte = Joint-cover in bitumised felt. — Feuilles de carton bitumé = Sheets of bitumised cardboard. — Naissances = Springings.

Half longitudinal section.



Cross section *a-b*.



Typical joint covering in bitumised felt to be used on the arch.

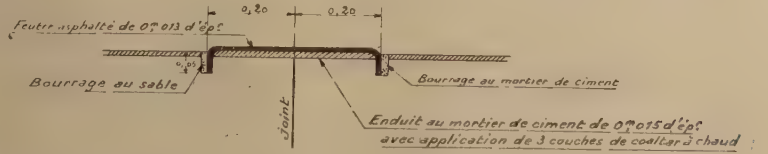


Fig. VIII. — Fexhe-le-Haut-Clocher to Kinkempois line. — Underline bridge of the « Rue du Perron », at Ougrée.

Explanation of French terms:

Couvre-joint en feutre asphalté de 0 m. 013 d'ép. (voir détails) = Joint cover in bitumised felt 1/2 inch thick (see details). — Enduit au mortier de ciment, etc... = Plastering in cement mortar 5/8 inch thick with 3 coats of hot coal tar. — Longueur de l'ouvrage = Length of the structure. — Parement en béton C1 = Wall in concrete C1. — Naissance voûte = Springing of the arch. — Niveau du chemin = Road level. — Rampe de 0 m. 0432 p. m. = Gradient 1 in 23. — Parements en moellons débrutis = Facings of roughly dressed ashlar. — Axe du chemin de fer = Centre line of railway. — Carton bitumé épais = Thick bitumised cardboard. — Joint = Joint.

cording to a certain coefficient of Poisson. This lateral thrust makes itself felt on the ground in contact with the foundations and in default of special precautions cracks appear in elevation. The phenomenon mentioned occurs quite regularly and experience shows the need for taking suitable precautions.

One of these precautions is to cut the arches at the joints so as to localise the movements, thereby depriving them of any effect prejudicial to the strength and appearance of the structure.

* * *

The drawings for these works have been prepared by the headquarters designing staff of the Belgian National Railway Company, with the collaboration of Messrs. Wasterlain, Clément, Degreef and Deryckere, engineers.

[656.251 (.45)]

Signal reform in Germany,

By E. W. RELEAUX, Assoc. I.R.S.E.,
Professor of Railway Engineering, Darmstadt Technical College.

(*The Railway Gazette.*)

In the Proceedings of the Institution of Railway Signal Engineers for 1926-27 there appears an intesting paper by Mr. T. S. Lascelles entitled « Railway Signalling in Germany », for 1928, one by Mr. C. W. Prescott on « Speed and Route Signal Aspects Compared », and for 1931 a further paper on « Ethics and Economics of Speed Signalling » by Mr. G. H. Crook. These papers encourage me to contribute something to these columns concerning the alteration made in 1930 to the German Signalling Regulations, which apply to all railways open to public traffic in Germany, for the basis of this alteration is the change from the route to the speed signalling principle. All along in German signalling the general principle followed has been to use as few signs or aspects as possible, to make them as clear and distinct as could be, and attach to them the most definite meanings that could be devised. It is the writer's opinion that the new regulations form a further step in the same direction.

The chief task of any signal system will always be first to indicate to the driver what course he is to pursue, that is to say, to order him to stop or sanction his proceeding, giving at the same time an instruction as to how fast he may move, and secondly, if it be necessary, to give him an indication of the route set up. A signal system based on the speed principle will thus give the most necessary information directly, while with the route principle the permissible speed must be deduced from the route indication. More important, however, than this process of thought is the practical disadvantage that with the route principle more indications are required, which easily leads to an undesirable multiplication of signals.

Adoption of speed signal aspects.

In figure 1 are given the various positions of a German home signal, with their old and new meanings. The actual aspects are being retained, although not quite to the fullest extent, as will be explained later. Their meanings, however, are altered. One arm inclined in the upper quadrant no longer means *Proceed on the through line,* but, according to the new explanatory instructions, *Proceed with the highest speed allowed in the working time-table, provided no other speed limit is prescribed by some special regulation, or a speed board.* Two or three arms inclined no longer indicate *Proceed on a diverging line,* but *Proceed with reduced speed,* such speed being, as a rule, for passenger trains on main lines 45 km. (28.13 miles) per hour, for goods trains, 30 km. (18.75 miles) per hour, whilst for all trains on light railways the latter limit applies. These new meanings do not at first appear to constitute any very essential alteration, for in most cases, though not invariably, the reduced speed is called for on account of a diverging line. There are, however, instances in which what, from a traffic point of view, is the *through line* leads over the diverging, or curved, portion of a pair of points. In spite of the use of special speed reduction signs, safety was not definitely

ensured at such places before, because the drivers were accustomed to look on the one-armed indication as permission to travel at speed. Figures 2*a* and 2*b* show the old and new signalling in such a situation.

Generally speaking, the necessity for the speed limitation prescribed by sig-

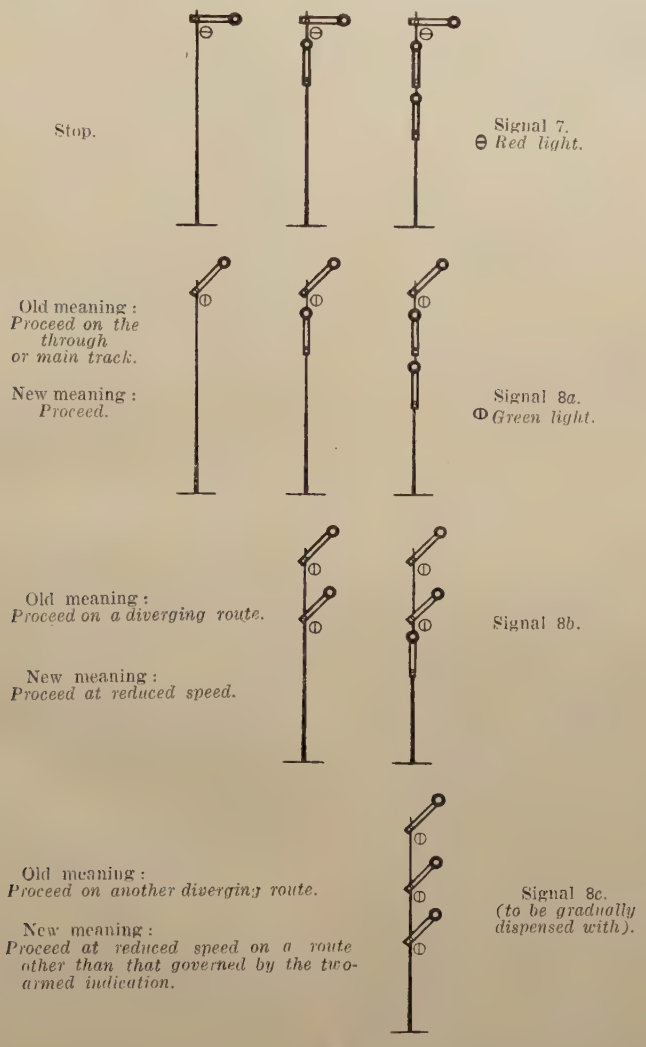


Fig. 1.

nal 8*b* or 8*c* should arise from the permanent form and situation of the line itself as, for instance, from the radius of a curve, from the existence of points, dead-ended lines, or insufficient—but incapable of being improved—superelevation on curves. For safety reasons the use of the two-armed signal is pre-

scribed for all cases where a speed limit of 60 km. (37.5 miles) per hour, or less is necessary. On the other hand, should a temporary necessity for speed reduction arise, as in the case of the condition of a movable bridge requiring it, or on account of work being carried out on the line or in connection with the signalling apparatus, then the two-armed

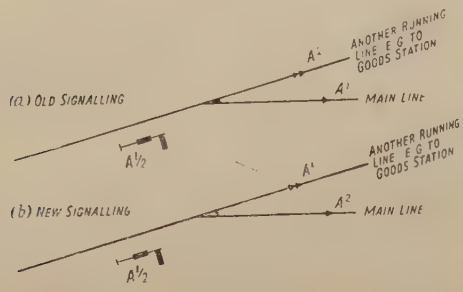


Fig. 2.

signal is not to be used to indicate it, but a special speed reduction sign is to be used instead.

As the speed reduction called for by the two-armed signal applies to the area immediately beyond it, the layout of which necessitates its employment, and must therefore be observed by the train by the time it reaches the signal, it ought to be signalled to it beforehand at the distant signal. It follows from what has been stated above that a speed limitation rendered necessary by the traffic conditions on the line, *e.g.*, the occupation of a block section ahead by a train, cannot be indicated by the two-armed signal in the way that it is by the signals on some rapid transit lines, as for instance on the Southern Railway around London. This function is performed exclusively by the distant signal, which gives notice of the approach to a *Stop* indication.

Turning now to the three-armed signal, it is to be remarked that this has essentially the same meaning as the two-armed one, but it prescribes a speed reduction over a route other than that governed by the two-armed indication. This constitutes a remnant of the route signalling method hitherto employed, but it represents only a transitional state of affairs; for in future, when it proves necessary to indicate to the driver both speed and route, this is to be done by attaching to the two-armed signal a route indicator, a device already well known in England, Norway, etc., and which, by means of figures, letters or other symbols —*e.g.*, by illuminated bars at night— indicates the route (figs. 6 and 7). The three-armed signal will thus gradually disappear, as will also the so-called directing signals, used hitherto ahead of the home signal proper, when more than three routes existed at a junction point (fig. 7). These directing signals, which are really not signals at all but sign-posts and for which the form of an ordinary home signal has, so to speak, been misused, are mostly found, it is true, as are the three-armed signals, on the former Prussian State system, while the other State systems in Germany usually contented themselves with the two-armed signal. When the abolition of the three-armed and the directing signals, already in hand for some time, is complete, then all indication of the route will have disappeared from the home signals in Germany and will be given, when absolutely necessary, by other means, such as route indicators.

The distant signal (fig. 3) remains as

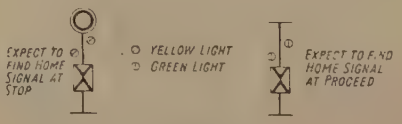


Fig. 3.

hitherto ; the vertical disc, placed on a short post at the level of the driver's eye, warns him to prepare to meet a *Stop* indication ; placed horizontally the disc means *Proceed,* either at full or at

reduced speed. This long-standing defect, the want of another indication at the distant signal, will be remedied before long. For many years trials have been conducted with the object of adding to the distant signal in the simplest possible way an indication ordering a reduction of speed. An account of one of these trials, being made on the Berlin-Hamburg section this year, appeared in *The Railway Gazette* for the 17 June last. In this connection it is interesting to observe that in the English signal system the problem is solved by the use of the route principle, since at junctions a separate distant signal is provided for each route, by means of which, by deduction from the route indication, the driver is made aware of the speed reduction required, he having a knowledge of the speed limits applying to each perticular route.

Whilst distant signals applying to home and intermediate block signals are generally worked in Germany by the same wire transmission and lever, distant signals repeating the starting signals at stations (usually placed close to the home signal post, or in Bavaria attached to it) are not, but are manipulated by a separate lever, so interlocked with the others that the inner distant signal, as we way term it in English for convenience, cannot show *Proceed* unless both the home and starting signals do so. When a train in the station receives the signal to depart and the entry on that line is consequently blocked, only the starting signal goes to *Proceed* and not its distant. Otherwise an approaching train which should, according to the time-table, run through, and has overlooked the home signal at *Stop*, might misread the inner distant signal and collide at speed with the other train. As similar dangers can arise at short block sections near the entrance to stations, distant signals in such sections have been fitted in addition with automatic replacer gear. In Saxony this independent working of distant signals has long been the rule.

In figures 4 to 11 a number of examples are given, part of them with the signals in the normal condition, which is *Stop* as in England, and part with them showing *Proceed* for certains routes. Figures 4 and 5 show two cases of junctions be-

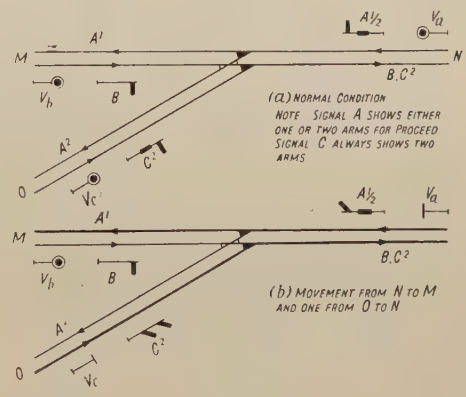

(a) Normal Condition
Note Signal A shows either one or two arms for Proceed Signal C always shows two arms
(b) Movement from N to M and one from O to N

Fig. 4.

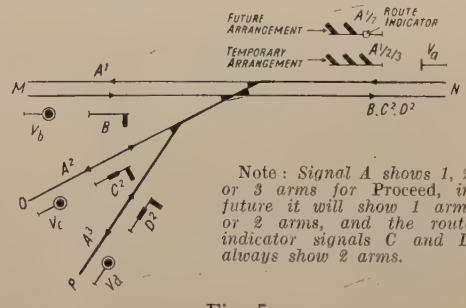

Future Arrangement
Route Indicator
Temporary Arrangement
Note: Signal A shows 1, 2 or 3 arms for Proceed, in future it will show 1 arm, or 2 arms, and the route indicator signals C and D always show 2 arms.

Fig. 5.

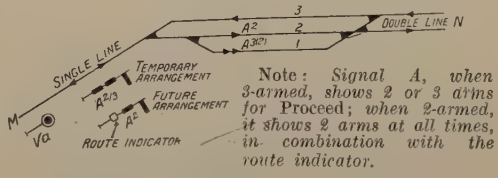
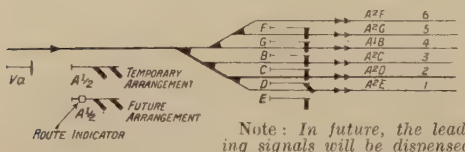

Single Line
Double Line
Temporary Arrangement
Future Arrangement
Route Indicator
Note: Signal A, when 3-armed, shows 2 or 3 arms for Proceed; when 2-armed, it shows 2 arms at all times, in combination with the route indicator.

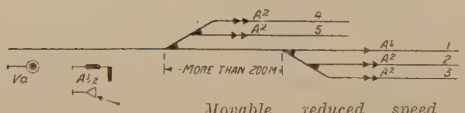
Fig. 6.

tween stations. In the latter example it is necessary to distinguish the three routes at signal A, so that the driver can detect in time any mistake made by the signalman. Previously this was done by using the three-armed signal,but in future a two-armed signal and route indicator will be employed. In figure 6 is shown the entrance to a station having two routes requiring reduced speed and which need distinguishing, in order that a driver sent by exception into line 3 may be able to realise it in time. Instead of using a three-armed signal, which can only show the two or three-armed indication, there will be used a signal with two coupled arms, working together, and a route indicator. Figure 7 is an example containing the old directing signals with six routes at the entrance to a station. Signal A can be set to *Proceed* only after one of the directing signals C to F has been cleared. These will in future be abolished and replaced by a route indicator. Figure 8 shows a case where the speed limits vary considerably. In order to distinguish them a supplementary signal, consisting of a movable speed board, illuminated at night, is placed near the home signal. If the routes are to be shown, too, then a route indicator will be used. In figure 9 a station is shown having overtaking facilities in one direction and a junction with a single line in the other. The indications of the signals for two movements are given : route indicators are not judged necessary in this instance. The application of the new rules to starting signals are also illustrated. For example, a one-armed signal B for the through main line X to Y, the other starting signals being two-armed signals, with coupled arms, C^2, D^2, because the layout of the routes imposes a speed limit. Such signals ought also to be used, strictly speaking, when trains do not run through but only start from the station, and thus in practice cannot attain too great a speed over the curved portions of the points. This, it must be admitted, leads to a considerable out-



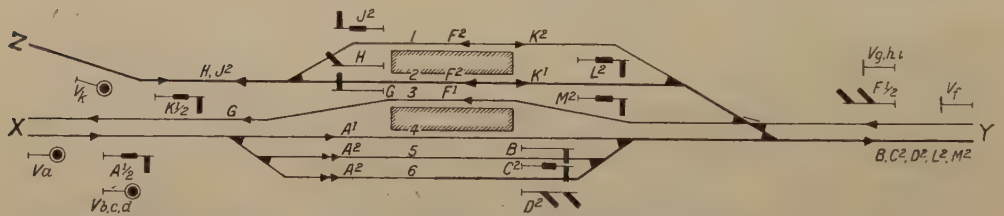
Note : *In future, the leading signals will be dispensed with and if absolutely necessary, the home signal will have a route indicator.*

Fig. 7.



Movable reduced speed board appears only for movements into track 4 or track 5

Fig. 8.

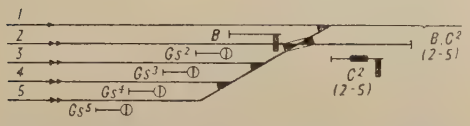


Note : Signal A 1/2 shows one arm for a movement into track 4, and two arms for track 5 or 6. A route indicator is not considered necessary for the traffic working in this case.
Signals C^2, D^2 always show two arms because the radii of the points necessitate speed reduction. The same applies for the opposite direction.

Fig. 9.

lay in equipping signals with two arms, which hitherto have needed only one. It is desired, however, to leave the one-armed signals only where full speed is permissible, in order to accustom the driver to a uniform system of signs everywhere. However, by the use of group starting signals, placed beyond the converging points of the various lines, such signals can be saved (fig. 10).

It may very well be asked whether the new regulations will suffice, whether in addition to the signal *Proceed* and *Proceed with reduced speed,* more definite speed instructions will not be required



Note: Group starting signal C^2 controls movements from tracks 2 to 5 in conjunction with their respective stop shunting signals Gs^{2-5}.

Fig. 10.

in many cases. This thought is impressed on one by reading the two English papers on speed signalling mentioned in the beginning. We believe it to be possible, in the interests of simplicity, to make do with the indications already explained. In the first place, we can place reliance on the driver's knowledge of the line, which is supported by local experience and by the appendix to the working rules, which contains a comprehensive description of the conditions in each section. Whenever special speed limits need announcing, speed boards (signal 38), with the speed limit inscribed on them, are being placed in position (see figs. 8 and 11). They form, as do the route indicators, a supplement to the home signals and their being fixed to the signal posts is quite conceivable.

A substantial improvement in the situation has been made by the recent development of light signals for use by day. It is permissible, with the consent of the Minister of Transport, to employ the corresponding night signals (figs. 1 and 3), in place of the arms and discs, in the form of colour light signals by day. In addition to the rapid transit lines in Berlin, Hamburg and Barmen-Elberfeld, trial sections have been is use on the German State Railways for some years, as in Lower Silesia. The missing third indication at the distant signal is given by means of two lights, yellow-green, placed in a slanting position, as those seen in figure 3. The results obtained with the light signals are, as in England, so good that their further application, leaving cost aside, is probably only a question of getting a reliable power supply.

The discussions and trials which have taken place for several decades now in Germany, with the object of improving the signal system, have been directed to the simplification on the speed signalling principle. One of the chief disadvan-

Fig. 11.

tages of the multi-armed signal is the amount of space which it occupies. With two arms even, and still more with three, it is often difficult to prevent the signal indication from being partially obscured by adjacent objects or, in the case of electric railways, by the overhead wire standards. In addition to this the operating mechanisms of multi-armed signals are more complicated and heavier to work than those of single-armed signals. The best semaphore signal to aim at is therefore the one-armed three-position type. A result of its use ought also to be to do away with the present defect of the night indications, in which, by the extinction of a lantern, a signal commanding reduced speed is

changed into a dangerous and misleading indication. The following system, due to Herr W. Stäckel, which uses the lower quadrant as well as the upper, comes up for consideration in consequence (fig. 12) :

Arm horizontal	= one red light	= *stop.*
Arm inclined downwards	= two yellow lights placed vertically	= *proceed at reduced speed.*
Arm inclined upwards	= one green light	= *proceed.*

Herr Cauer has put forward another proposal for a three-position signal of this type, but he employs green and red only, as double lights placed horizontally, the fundamental principle of the signal indications being that the extinction of a green light cannot create a dangerous indication, and should a red light fail, the other still remains (fig. 12), thus :

Two red lights, placed horizontally	= *stop.*
One green light	= *proceed at reduced speed.*
Two green lights, placed horizontally	= *proceed.*

This proposal, which has been developed in somewhat similar form in Belgium and Norway, has the advantage of being particularly distinctive and of

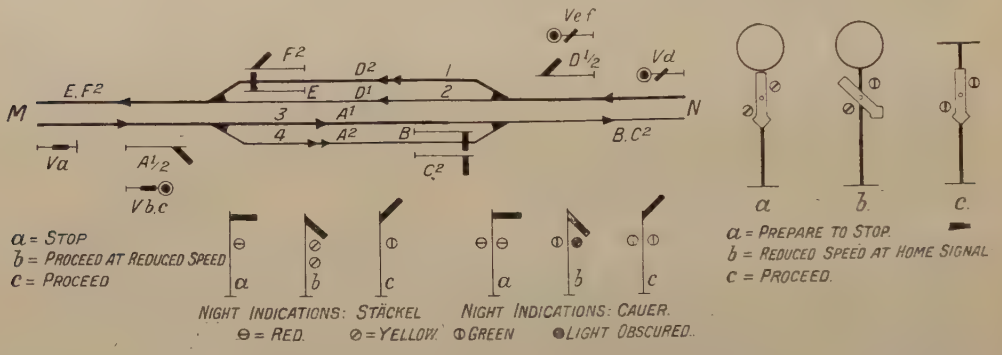


Fig. 12.

keeping the yellow light to the distant signal. Nevertheless there is the disadvantage that additional lanterns would be required and that in making the change from the existing system — replacement of double green meaning by single green — certain difficulties would be met with. In figure 12 an example is given of the one-arm system in conjunction with one of the new proposals for a three-indication distant signal. Whether it can be introduced depends on whether money will be available for the purpose, and indeed the regulations of 1930 will only come into operation gradually, for a similar reason.

[621. 134. 1 (.42)]

The manufacture of monobloc cylinders for 3-cylinder locomotives.

Details of the practice applied at the Doncaster Works of the London & North Eastern Railway,

By R. A. THOM,

Mechanical Engineer, Doncaster, London & North Eastern Railway.

(From *The Railway Engineer.*)

The design and manufacture of cylinders is one of the principal technical problems with which the locomotive designer has been confronted. In the early days, the equipment of the foundry and machine shops was such that it was necessary to cast the comparatively small cylinders in use at that period separately and bolt them together before erection on the engine frames. Since then, however, there has been considerable development both in cylinder design and in the equipment available for manufacture. Cylindrical valve chests for the accommodation of piston valves have been generally introduced. The placing of larger cylinders outside the frames and the use of outside valve gears have necessitated steam and exhaust passages entirely different from the earlier designs, while the power and economy demanded from the modern locomotive makes the provision of either three or four cylinders an absolute necessity. The design and production of a complete set of cylinders for a modern locomotive presents a problem as great as any to be met with in general foundry and machine-shop work, and until quite recently it was the usual practice, where more than two cylinders were required, to cast them in two or three separate parts and bolt them together to form the complete unit. Such an arrangement, however, has distinct disadvantages on account of the large surface joints which must be maintained steamtight between the two or three separate castings, and in the number of bolts required to do this and to secure the castings in position in the frames.

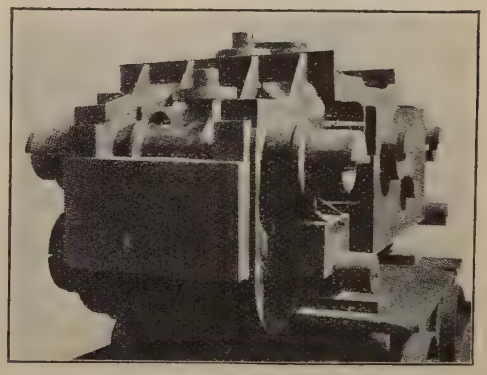


Fig. 1. -- Main pattern for three-cylinder casting.

In designing the locomotive cylinders now under review, Mr. H. N. Gresley, chief mechanical engineer, London & North Eastern Railway, combined the cylinders, valve chests, and steam and exhaust passages to form a monobloc casting. The design, having been settled, the first operation is that of pattern-

making. Complete patterns in wood of the whole of the outside surfaces, and core boxes in which can be moulded sand replicas of the whole of the inside surfaces, are made, and in order to accomplish this the drawings with all the various views and sections are set out on large boards — some of these are shown in figures 2 and 3. The unit of measurement used for the production of these drawings is not the standard inch but is one-eigth of an inch per foot larger to allow for the contraction of the metal when cooling. The dimensions on these drawings, therefore, and the wooden patterns made from them, are proportionately larger than the full size of the finished casting.

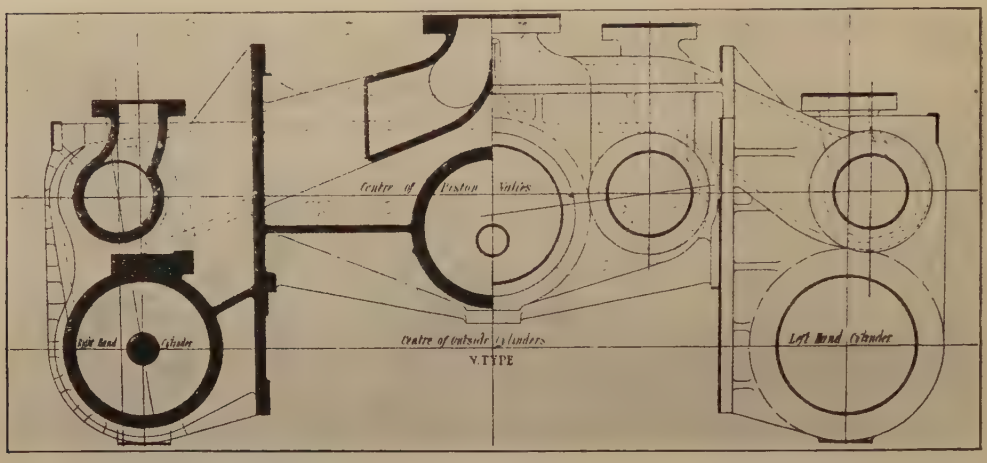


Fig. 2. — Elevation drawings used in preparation of patterns for three-cylinder casting.

The main patterns are shown in figure 1. They ade made in three main sections for purposes of moulding in a three-part moulding box. The divisions can be distinctly seen, the lower one through the horizontal centre line of the outside cylinder barrels and the upper one through the centre line of the valve chests and inside cylinder barrel. The flanges on the upper portion, and the smaller projections to which wire is attached, are detachable from the pattern for the purpose of withdrawing the various sections from the mould. The extensions at the end of the cylinder barrels, valve chests and the rectangular portion at the side of the cylinders are for carrying and locating the sand cores.

When the patterns and core boxes are completed the work in the foundry is commenced. For convenience in arranging the mould and pouring the metal, and because the greater proportion of the metal is in the upper part of the casting, the mould is made with the cylinder barrels uppermost. Progress in the construction and building up of the mould can be followed readily by reference to figures 4 and 5. In figure 4 the sand core produced by the core box has, with several smaller cores, been placed in position.

Great care is taken in locating these cores in order that their distances from the adjacent sand surfaces and the ultimate thickness of the metal may be uniform. The mould is then ready to

receive the cores for the internal surfaces of the steam chests and that for the bore of the middle cylinder. These are shown in position with the steam port cores and the remaining portions of the exhaust cores in figure 5. The cylindrical cores are built up with a hollow steel centre to allow any moisture or gases to escape.

This completes the first section of the box, and in the meantime the second section has been in preparation. In this second portion some of the small horizontal ribs to the cylinder flange can be seen, and when it is realised that the pattern has had to be withdrawn the necessity for making these detachable from the pattern becomes obvious. At this

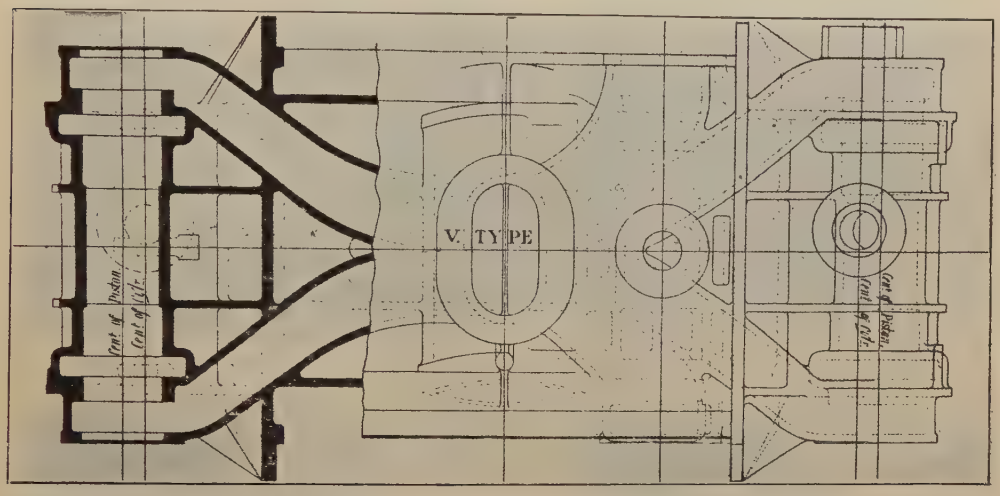


Fig. 3. — Plan drawings used in preparation of patterns for three-cylinder casting.

stage the mould is ready to receive the cores for the outside cylinder barrels, while the whole of the centre portion is closed by means of an auxiliary mould. This completes the midle part of the box and takes the mould to the cylinder centre line where the second division of the pattern was made, and there remains to be made the mould of the lower part of the cylinder barrels.

The mould is then prepared for pouring in the molten metal. A runner box connects each of the four holes down which the metal will flow. These holes are plugged with steel plugs and they remain so until the runner box is filled with metal, when they are withdrawn and allow the metal to pass to the bottom of the mould and feed the casting equally from each of the four corners.

The weight of the casting is 4 tons 15 cwt., but approximately 6 tons of metal are required in the process of casting. It takes three days for the metal to cool sufficiently to allow the casting to be taken from the sand. This is necessary to prevent uneven stresses which would be set up in the casting if allowed to cool quickly, and to prevent any chilling and hardening effect on the surfaces to be machined.

The casting as lifted from the sand is shown in figure 6. The lines of division of the pattern and moulding box can be distinctly seen, a thin film of metal having penetrated into the joints. The

Fig. 4.

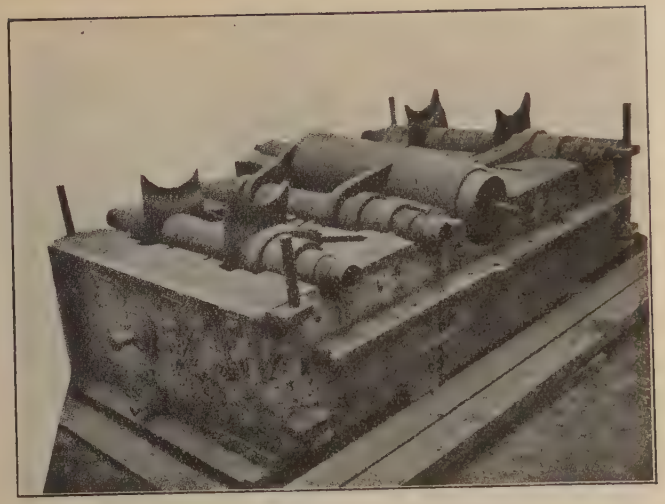


Fig. 5.

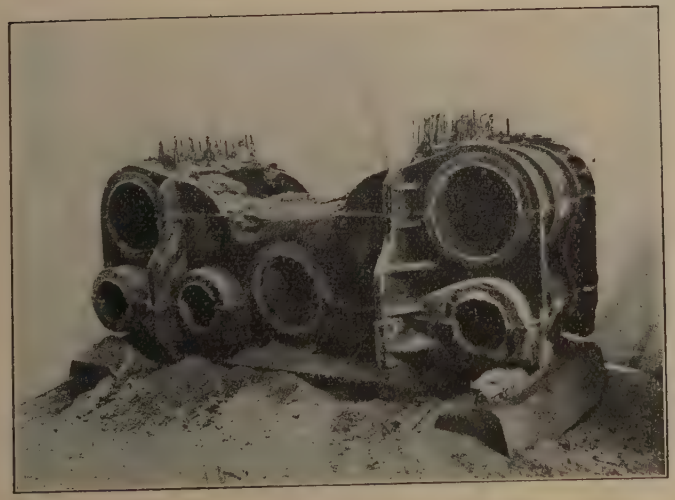


Fig. 6.

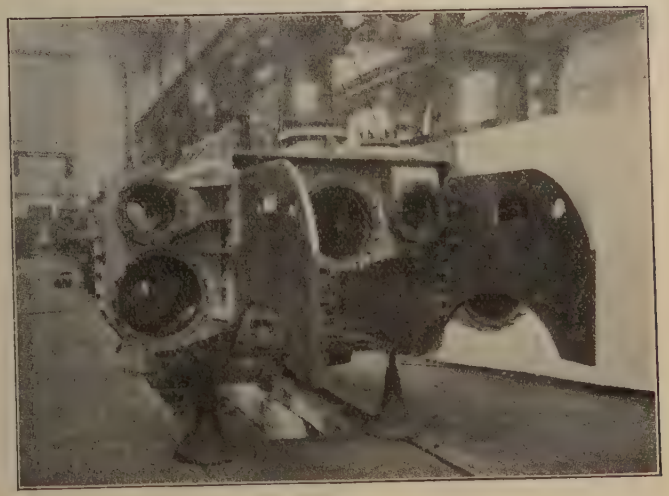


Fig. 7.

Stages in the construction of a three-cylinder casting : building up the mould, the cores in position, the rough casting, and the finished work.

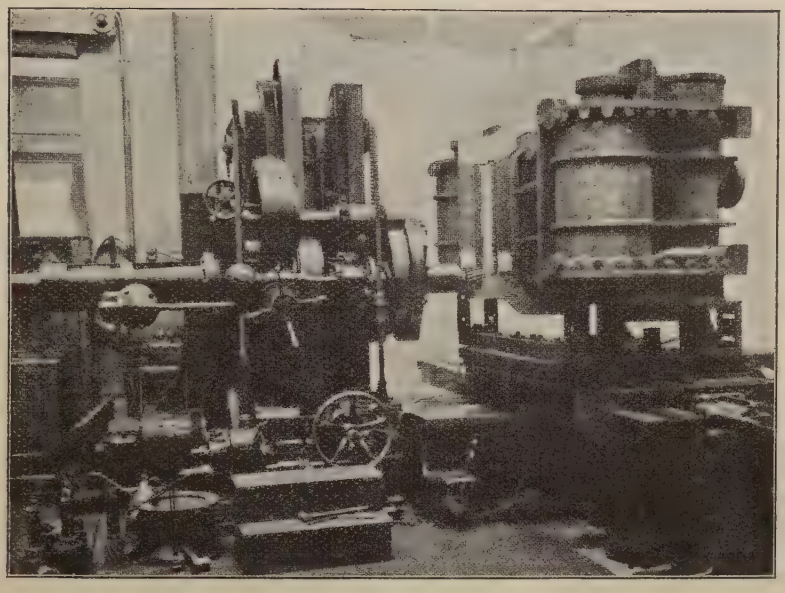


Fig. 8. — Machining cylinder casting.

irons in the top and at various other points are those which had been inserted in the larger volumes of sand to hold it in position and assist in maintaining its correct shape. The casting in this condition is ready for fettling, which consists of removing all the sand and surplus metal, and generally trimming and cleaning. From the time of pouring the metal until the casting is ready for the machine shop is approximately one week.

By an examination of the casting it will be realised that the old types of planing and boring machine do not lend themselves to machining a casting of these dimensions as easily as when each unit is cast separately, but by the use of a modern type of universal milling and boring machine any difficulty in machining is overcome; by the introduction of the monobloc type the amount of machining and fitting is considerably reduced. The relation of the cylinders also to each other and their various inclinations can be set with precision in the machine shop and save time and ensure greater accuracy than when setting the separately cast cylinders in the erecting shop.

Figure 8 shows the machine on which the principal work of machining is carried out. The cutter being used is a rotary-type milling cutter and as well as having a rotary motion traverses in the vertical plane. The movement of the table on which the cylinder rests is in either of the two horizontal planes while the upper portion, together with the casting, may be revolved completely round. The operation in progress, which is the first machining operation, is that of milling the inside of the cylinder flanges to the standard distance over the engine frames. This is done at both front and back ends at this setting, after which the cylinder is reset and the machining of this portion of the cylinder flange completed.

The design undoubtedly introduces a casting of such dimensions that its manufacture is only possible in the foundry and machine shop which are suitably equipped with modern machinery, but the reduction in the amount of machining required, the elimination of joints between separate castings, the simplification of erection and the reduction in the number of bolts, render it a distinct advance upon the usual method of producing the cylinders in separate units.

[625. 234 (.73)]

Illinois Central de luxe cars are air-cooled.

(From *The Railway Mechanical Engineer.*)

The de luxe « Daylight Special » train of the Illinois Central, operating between Chicago and St. Louis, Mo., has recently been completely equipped with the new air-conditioning system developed by the Westinghouse Electric and Manufacturing Company. Ten air-conditioning units, each producing a cooling effect equivalent to the melting of six tons of ice in 24 hours, were installed on a total of 10 cars, including two diners, two lounge cars, two parlor cars, two chair cars and two baggage-smoking cars. Railroad forces at the Burnside (Chicago) shops of the Illinois Central performed all of the work of installing the equipment, including air ducts, distribution grills, etc.

The Westinghouse air-conditioning equipment consists essentially of three self-contained units, as follows : A 15-kw. gear-driven axle generator which supplies power for air conditioning, car lighting and battery charging ; a six-ton refrigerating unit complete in one box for underframe mounting ; an air-conditioning unit mounted under the car roof.

Electrical equipment.

The necessary generator and motor controls are mounted in the customary lighting control cabinets. Since the existing generators are not required, the entire system adds only about 4 500 lb. to the car weight. No floor space is taken and the system requires no replenishment of water or similar servicing.

The power source is a 15-kw. gear-driven axle generator, designed with ample capacity to provide power for air conditioning, car lighting and battery charging. The generator is mounted on the truck in essentially the same manner as a driving motor on any electrically operated multiple-unit car. This type of drive, in successful use for many years, requires a special axle, but has the advantage of completely eliminating all belts, spline shafts, universal joints, etc. The generator and drive are suitable for application to either four-or six-wheel trucks.

The axle generator is a totally enclosed 32-45-volt machine. The frame is designed with a large number of radiating fins to take advantage of the train movement, thereby cooling the generator and enabling a large service capacity to be obtained from a small unit. The rating of the generator is 20 kw. for one hour and 15 kw. continuously. The generator, at these ratings, operates considerably below the American Institute of Electrical Engineers' allowable temperature rise for Class B insulation. The mechanical design of the generator follows standard railway motor practice.

On the commutator end of the generator shaft is located a small two-pole exciter. This exciter serves several purposes. It provides the necessary and

proper excitation for the generator, and by controlling only the exciter fields with the regulator, a very conservatively applied regulator is had. The exciter is constructed with special iron in the field structure which insures high retentivity. The housing between the generator and exciter is of non-magnetic material. With an exciter of this character, the generator always builds up with the same polarity irrespective of train direction, eliminating all brush shifting devices.

Gear drive for generator.

A 1 000-amp.-hr. battery is used in conjunction with the generator for supplying power during intermediate stops and at slow speeds. Tests made on the car indicate that the generator will cut in and remove the compressor load from the battery at 18 m.p.h. With the gear ratio employed on the drive, the generator is safe for continuous operation at 90 m.p.h.

The generator is directly driven from the axle by a gear unit to which it is mounted. The axle is pressed into the gear unit which is held onto the axle by two roller bearings. On the axle is mounted a flexible gear similar to those used on M-U cars and locomotives. The gear drives an idler gear which in turn drives the generator pinion. The idler gear is used because of center-sill clearance only. High angle helical gears are used throughout to prevent noise, and within the car no gear noise can be detected. The entire gear operates in oil, providing positive lubrication.

The principal objection raised to gear drives of this sort is the stress imposed on the gears when coupling trains. Tests were made with accelerometers before designing the gears, and the teeth are constructed to withstand any impact which would slip the car wheels. However, as a further protection, a flexible feature has been incorporated in the gear drive.

Generator control.

The control for a generator to handle the loads imposed on a car should provide the full generator output at all speeds from the minimum to the maximum, but at the same time give the proper taper for battery charging. The voltage should also not vary with sudden applications of compressor loads. These conditions have been met on these cars.

A regulating relay controls the exciter fields which have been divided into three sections. At low speeds, all are in series to provide maximum excitation. At intermediate speeds, part of the field is cut out, and at high speeds the differential field opposes the main field. With this system, no carbon-pile resistors are used. The regulator is extremely stable under all conditions, and maintains the voltage to plus or minus one-half volt. Application of large concentrated loads produces less than one volt fluctuation,

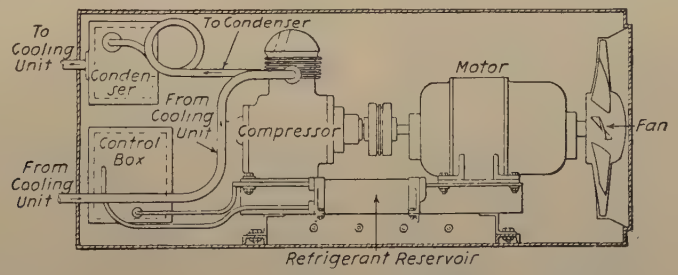


Fig. 1. — Diagram showing principal elements of the Westinghouse Electric & Manufacturing Company's air-cooling equipment.

and the voltage immediately returns to its previous value. The regulator may be adjusted for any voltage from 32 to 45 volts by means of a set screw.

A taper-charge feature for the battery, for this service, cannot be built into the regulator for it is essential that constant voltage be maintained on account of the compressor. To give the proper taper charge, a modified constant potential-system is used, employing a series resistor in the battery circuit.

The automatic switch is mounted on the same panel as the regulator. It operates to open or close the generator circuit to the battery at a voltage differential of plus or minus one-half volt, thereby causing no surges when the generator cuts in.

The refrigerating system.

The entire refrigerating system is mounted under the floor in one box about the size of a large battery box. This box is designed for bolting to the car underframe, and requires only two pipe connections from the cooling coils

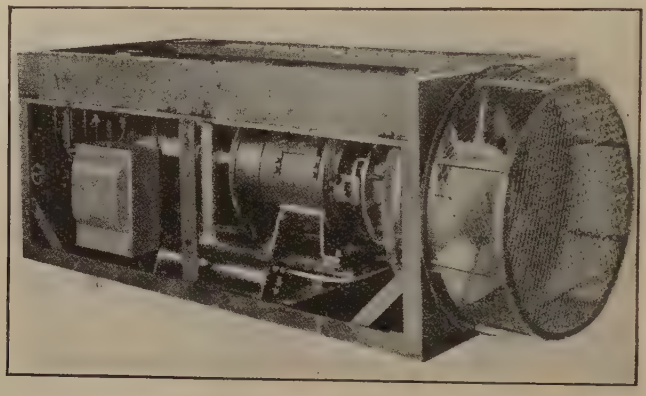


Fig. 2. — Six-ton refrigerating unit ready for mounting under the car.

and the motor leads. The condenser is air cooled.

The equipment is readily accessible from the side of the car by unlatching two doors. In the box is contained the following apparatus. Air-cooled condenser, six-ton compressor, a.c.-d.c. motor, condenser fan, liquid receiver tank, oil separator, cut-off valves, strainer, and a.c. starting switch.

By closing a small control switch, the entire plant is placed in operation. By opening the compressor switch, however, the ventilating fans may be operated without the refrigerating system. The refrigerant used is Freon. The compressor pumps gas at high pressure into the air-cooled condenser, where it is condensed to a liquid. From there it goes to the cooling unit in the roof where the liquid expands to a gas and cools the car. It returns through an oil separator, which returns any oil to the compressor crank case, and the refrigerant passes into the compressor. The cycle is then repeated.

The condenser fan is bolted to the driving motor. The motor is directly connected to the compressor and all mounted on a bed plate which is carried on rubber so that no objectionable vibration is passed to the car. The condenser is mounted in the rear of the box so that air enters at one end and goes out at the rear through the condenser coils.

At the end opposite the fan are located three valves and the strainer. One valve shuts off the back-pressure line and one the high-pressure line. The third cuts off the strainer, enabling it to be removed without losing any refrigerant. Similarly, all the charge may be pumped into the receiver tank for any pipe repairs.

The principal feature of the refrigerating unit is the high-speed compressor which develops six tons of refrigeration with a weight of only 300 lb. Operating at 1 000 r.p.m., a high efficiency is said to be obtained. The crank shaft, pistons, connecting rods, bearings, etc., are all force-lubricated by an oil pump located in the crank case. Flapper valves are used.

The condenser cooling fan was especially developed by the manufacturer in its research laboratory for efficient use in this application. The fan is made entirely of aluminium.

One of the biggest problems in air conditioning of cars is that of pre-cooling. For midnight sleepers which may be parked for several hours, the use of

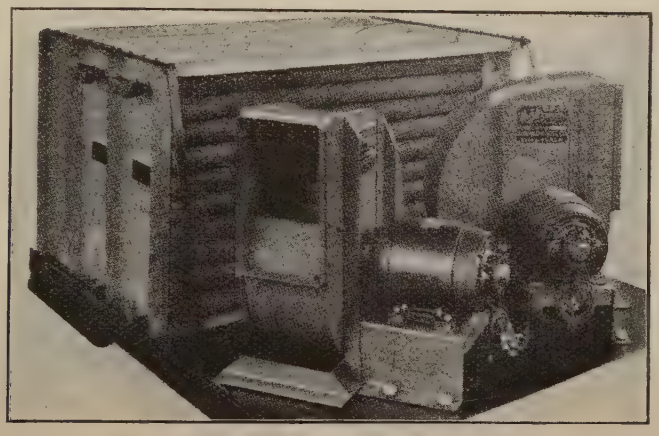


Fig. 3. — Air-conditioning unit and direct motor-driven fans which are installed under the car roof.

a battery is out of the question. Wiring yards and terminals at 32 volts is expensive. Realizing this, the manufacturers designed an a.c.-d.c. motor drive for the compressor which requires no more space than a standard d.c. motor.

This motor is a two-bearing set, directly connected to the compressor. The d.c. end operates at 1 000 r.p.m., 38 volts, and rates 10 H.P. totally enclosed. The a.c. end rates 15 H.P. at 1 150 r.p.m., either 220 or 440 volts, 60 cycles, 3 phase. This arrangement gives universal operation from either a.c. or d.c. power. For operation at slow speeds or during intermediate stops, the battery is used. For operation above 18 m.p.h., the generator furnishes power. During pre-cooling, commercial a.c. power may be used. Another feature of this drive is the ability to charge the battery when operating from the a.c. end. By merely closing the compressor switch, the d.c. motor, operating as a generator, automatically charges the battery. The a.c. feature increased the weight of the equipment about seven per cent. This is the only motor used in the refrigerating unit.

Air-conditioning units.

The air-conditioning apparatus is mounted in one unit located under the

car roof. The unit consists of the cooling radiators, blowers, capillary tubes and a regulating valve. A heating radiator is included for winter heating of the car.

The high-pressure line from the refrigerating unit runs to the regulating valve which controls the amount of liquid to keep a constant back pressure. From this valve, the refrigerant is distributed evenly to the radiators. Air is pulled through the cooling radiators by the blowers and then delivered to the car. A definite amount of fresh air is taken from the outside at all times through filters, and a certain amount of air recirculated. No expansion valves are used and only 25 lb. of Freon is needed to fill the system.

To facilitate the duct arrangement, two No. 2 Buffalo Forge fans are used, each driven by a 1/2 H.P. motor. The fans are set at an angle of 60° to eliminate any right-angle bends in the ducts. These fans deliver air in excess of 2 000 cubic feet per minute to the car. The control is so arranged that the compressor cannot be operated without the fans, but the fans can be operated without the compressor.

Fig. 4. — Westinghouse motor-driven compressor and condenser mounted under the car body.

All the air entering the car, either winter or summer, passes through filters and is cleaned before the warming or cooling process, as the case may be. A thermostat, which may be set for any desired temperature, controls the refrigerating apparatus whether operating from the battery, the generator or a.c. power. For winter operation, the heating radiator is used. This supplements the regulator heating system and tempers the fresh air supplied to the car.

Air is supplied to each car interior by two ducts, one along each side of the deck. Each duct has a cross-sectional area of about 100 sq. inches with uniformly spaced louvres from which the air enters the car.

Four of the Illinois Central cars, equipped with the Westinghouse air conditioning system, have turtle-back roofs, while the other six cars have roofs of the standard monitor type. On the latter type, the air ducts, installed on the outside of the car and using the present ventilators as inlets, are designed to give a turtle-back effect. On the other cars, the ducts are installed inside the car and consist of triangular-shaped ducts, located at the deck molding on each side of the car and encased in 1/2 inch laminated wood which carries the deck finish and gives the monitor interior effect.

The ducts are of uniform size, the full length of the car, deflectors being provided at the louvres, so arranged as to regulate the delivery. In all cases, the air ducts are made of 14-gage steel, with 1 1/2 inch hair-felt insulation.

[621. 335 (.494)]

New single-phase electric locomotive built by the Oerlikon Company for the Saint-Gothard Line (Switzerland).

(*Le Génie Civil.*)

The Saint-Gothard line, which starts from Lucerne and runs down into Italy after going through the Alps in the great tunnel 14.29 km. (8.88 miles) long, driven with great difficulty between 1872 and 1882, ends at the frontier station of Chiasso near Como after passing through Bellinzona and Lugano.

The fiftieth anniversary of the opening of this line, which diverted a notable proportion of the traffic from Germany and its neighbouring countries (Belgium and Holland) to Italy, was celebrated on the 1 June 1932, by the inauguration of a commemorative monument at Airolo station, at the southern end of the tunnel, and by various official and popular celebrations.

The difference between the steam traction as practised half a century ago on this heavily graded line and the electric working which succeeded it some ten years ago is very great : the latter has been much improved by the recent putting into service of a 8 800-H. P. locomotive (figs. 1 and 2) on two articulated trucks, which holds the record at the present time for power, and of which we give a general description below.

Until the last few months the most powerful locomotive was that of the Virginian Railroad (U.S.A.) of the 1D1-1D1-1D1 type, i.e. consisting of three units with twelve pairs of driving and six pairs of carrying wheels with a driving axle load of about 35 tons. Its power at the hourly rate is 7 125 H.P. at 45.5 km. (28.3 miles) per hour, and the corresponding tractive effort is 42 300 kgr. (93 230 lb.). In Europe, the Paris-Lyons-Mediterranean Railway had held the lead as regards the power of locomotives with its $2C_0C_02$ type engines (six pairs of driving and four pairs of carrying wheels) (1) which are used on the Mount-Cenis line (Culoz-Modane), the power of which is 5 400 H. P. This type still holds the record for locomotives with a single body.

The new locomotive, No. 11851, built for the Swiss Federal Railways by the Oerlikon Company in collaboration with the Winterthur Locomotive Company, has been designed to work over the 1 in 37 gradient of the Saint-Gothard line express trains weighing 600 tons at 62 km. (38.5 miles) per hour and goods trains weighing 750 tons at 50 km. (31 miles) per hour. To satisfy these conditions it had to have at least eight driving axles. Owing to the resulting length, it was decided to build it as two symmetrical trucks close coupled together. In order to get good running on curves which is essential for locomotives working over mountain lines with many curves of small radii, three pairs of carrying wheels were provided per truck, one at each end, and one in the middle; these

(1) The notation C_0 as subsequently the notation B_0 refers to individually driven driving wheels (three pairs for C_0, and two for B_0), whereas the notation D used in connection with the Virginian Railroad engine means that there are four pairs of coupled wheels.

Fig. 1. — New locomotive built by the Oerlikon Works. View taken in Airolo Station, on the Saint-Gothard line.

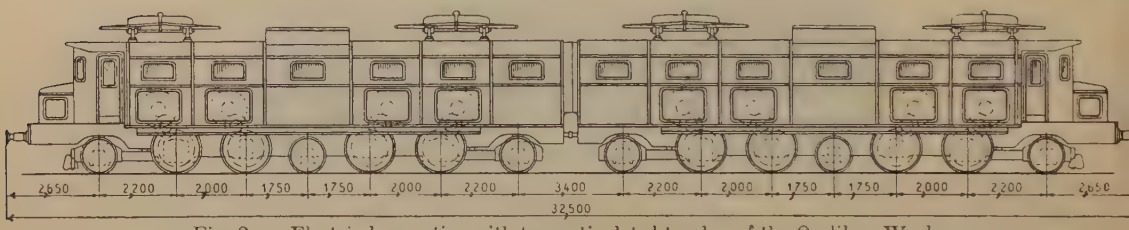


Fig. 2. — Electric locomotive with two articulated trucks, of the Oerlikon Works.

wheels also carry the excess weight over the 20 tons allowed per driving pair. The arrangement of the axles therefore corresponds to the notation $1B_01B_01 + 1B_01B_01$. At each end of each of the two half locomotives there is a four-wheeled bogie formed by the carrying pair and the adjacent pair of driving wheels; all these pairs of wheels have side play so that the running on curves is quite satisfactory.

The Swiss Federal Railways use single-phase current at 15 000 volts, 16 2/3 periods per second, reduced to the motor voltage on each locomotive by one or several transformers. In this instance a transformer is provided at the middle of each body above the carrying pair of wheels and for the first time in Switzerland the individual axle drive known as the « universal » drive designed by the Winterthur Locomotive Company has been used. The details of this drive are arranged on the longitudinal centre line of the locomotive and the two motors of each axle are placed face to face symmetrically relatively to this centre line. By moving them towards the nearest end of the half-locomotive instead of putting them exactly over the axle, space was made for the transformer.

The commutators and the motor pinions are arranged towards the centre and the pinions drive the wheels of a gear set, the pinions of which in turn drive a toothed wheel forming part of

a hollow shaft surrounding the axle and containing the articulated mechanism which allows of relative movement between the hollow shaft and the axle.

With a very heavy train in bad weather the adhesive weight may be insufficient to prevent the driving wheels slipping when starting. To overcome this, above each middle pair of wheels a cylinder is fitted which works with compressed air and is used to transfer part of the weight on the wheels in question to the driving wheels; by this means the adhesive weight can be increased by 12 tons.

The space between the motors on both sides of the locomotive is occupied by the centre gangway, from which the commutators and brushes of the motors and all the other electrical equipment arranged thereabouts (reversers, motor fans, main switch) can be easily got at. The traction motors are taken down from the outside after removing a side panel of the body.

The two motors driving each pair of wheels being series coupled, there are in each half-locomotive four groups of two motors wired in parallel and connected with the secondary winding of the transformer, the middle point of which is earthed.

The speed is regulated by varying the voltage at the motors as is the case on all locomotives on the Federal Railways. Hitherto this variation has been got by connecting the motors to the different tappings of the low voltage winding of the transformer, whereas in the present case the tappings are on the high voltage side which has made it possible to build the graduating equipment for a much lower current intensity; against this, the voltage is much higher.

The locomotive is fitted for regenerative braking according to the arrangement used by the Oerlikon Company since 1918, as for example on all the electric locomotives supplied by them to the Saint-Gothard line.

Leading dimensions of the 8 800-H. P. Oerlikon locomotive.

Length over buffers	34 m.	(111 ft. 6 3/4 in.)
Total wheel base of a half locomotive	12.50 m.	(41 feet)
Total wheel base	29 m.	(95 ft. 1 3/4 in.)
Diameter of the driving wheels	1.35 m.	(4 ft. 5 5/32 in.)
Diameter of the carrying wheels	0.95 m.	(3 ft. 3 1/8 in.)
Gear ratio		1 : 3.47
Number of traction motors		16
Power, hourly rate, measured at the motor shaft		8 800 H. P.
Corresponding tractive effort	38 300 kgr.	(84 875 lb.
Corresponding hourly speed	62 km.	(38.5 miles)
Continuous power measured at the motor shaft		8 300 H. P.
Corresponding tractive effort	34 500 kgr.	(76 060 lb.)
Corresponding hourly speed	65 km.	(40.4 miles)
Maximum speed	100 km.	(62 miles)
Approximate maximum tractive effort at starting	60 000 kgr.	(132 280 lb.)
Approximate weight of the mechanical part	125 t.	(123 Engl. tons)
Approximate weight of the electrical part	119 t.	(117 Engl. tons)
Approximate weight of the locomotive	244 t.	(240 Engl. tons)
Approximate load per pair of driving wheels		20 tons.

The motor armature is put into series with an impedance coil and the winding of the main field is in parallel with the armature circuit. These connections are made by the reverser in service; consequently, when regenerating, each half locomotive has four circuits in parallel, each consisting of two armatures, two compensating and auxiliary pole windings, and an impedance coil connected in series, and a fifth circuit parallel to the others and formed by the windings, connected in series, of the main poles of the eight motors. The specification laid down the condition that the locomotive had to be braked electrically with complete safety on the 1 in 37 gradient so that it could run down the full length of the gradient at the constant speed of 35 or of 65 km. (21.75 or 40.4 miles) an hour. It was also specified that it must be possible to reduce the speed of the locomotive on the same gradient from 65 to 5 km. (40.4 to 3.1 miles) per hour in a maximum of two minutes by means of regenerative braking alone. These requirements were not only met, but the regenerative equipment is able to brake the whole train to a full stop.

Besides the electric brake the locomotive is fitted with hand and compressed air brakes. The air brake is fed by a reciprocating compressor of 3 000 l. (106 cubic feet) per minute capacity.

The power of the traction motor was fixed by the specification at the following values, measured at the motor shaft :

Hourly : 450 H.P. at a speed of about 62 km. (38.5 miles) per hour.

Continuous : 410 H.P. at a speed of about 66 km. (41 miles) per hour.

The above table shows these requirements are largely exceeded.

When comparing these tractive efforts with those of other locomotives, it must be remembered that the temperature rises allowed by the American 1915 standard and followed in these specifications are relatively low, and if other standards allowing higher temperatures are used, for example the German 1925 standards or the new American standards, the power and the tractive effort would be still greater.

The traction motor gives, according to the trials, a power of 550 H.P. at the hourly rating instead of the 450 required, and a continuous power of 520 H.P. instead of 410. It is always satisfactory to have such an excess of power, even if it cannot be fully used, because the motor does not have to be worked at full power constantly and this reduces its maintenance and lengthens its life.

The Oerlikon locomotive No. 11851 has made its trial runs, with the prescribed trains of 600 tons in the case of fast trains and of 750 tons for goods trains, with excellent results; brake tests of the complete train have been carried out using the regenerating electric brakes only, during which the train was brought to a stand.

* * *

To complete this information, we may mention here that the Federal Railways have also had built for the Saint-Gothard line a similar locomotive numbered 11801 by the Brown-Boveri Company in collaboration with the Winterthur Locomotive Company. The chief difference between the two locomotives in question is in the drive of the driving wheels : in this latter case each of these pairs of wheels is driven by a single motor directly mounted on it in the way adopted by the Brown-Boveri Company for some time. The power is less than that of the Oerlikon locomotive; according to the *Schweizerische Bauzeitung* of the 19 March 1932, which published an article on these two engines, it is of 7 000 H.P. (continuous rating) at the speed of 59 km. (36.7 miles) per hour, with a tractive effort of 31 000 kgr. (68 340 lb.), [maximum starting effort : 50 000 kgr. (110 230 lb.)].

[385. (06 .11]

Final summaries adopted at the twelfth Session, Cairo (January 1933).

SECTION I. — Way and works.

QUESTION I. — The protection of level crossings in view of modern developments in road traffic.

Summary.

« 1. As thanks to the use of motor « vehicles, road traffic, formerly local, « has been transformed into high-speed « traffic and becomes more and more in- « ternational, the Congress invites all « countries to adopt legislation and re- « gulations inspired by uniform prin- « ciples relating to the protection of level « crossings and the types of signals.

« 2. The most effective solution as re- « gards the crossings of the roads with « the railways, the construction of over « and under-passages, can only be app- « lied in limited cases to crossings of « roads with very heavy traffic, with « main line railways. This solution « cannot be taken into consideration as « a more or less general rule in view of « the exorbitant cost it would involve.

« 3. In the *United States* the number « of guarded level crossings is diminish- « ing : in 1927 it was only 5 957 out of « a total of 232 000 level crossings. In « certain States the gates are not con- « sidered as satisfactory for fast road « traffic and they are replaced by a « *written notice*, a *flashing sign* or by a « *keeper* on the site, who stops the road « cars when a train arrives.

« In *Europe*, on the contrary, there are « methods still in use which relate to « times when the road traffic was quite « different from the present. Efforts « are now made to announce the arrival « of trains at guarded level crossings with « heavy traffic on either railway or road « and in case of insufficient visibil- « ity towards the railway. The suppres- « sion of gates would, however, signify a « progress because the halts on the road « would be reduced to a minimum and « the risk of accidents caused by closed « gates independently of the passage of « trains, would be eliminated.

« 4. In the case of level crossings « where the traffic is of average in- « tensity, it is desirable to consider that « an appropriate signalling gives a de- « gree of protection which is not in- « ferior to that given by the gates and « has this advantage that it interferes « less with the road traffic and prevents « the accidents resulting from collisions « with the gates, so frequently reported.

« If the signalling of level crossings is « required by the law it must be well « understood that the railway adminis- « tration is not responsible for accidents « occurring at level crossings, in the « same way as the road administration

« is not responsible for accidents occur-
« ring at crossings of public roads.

« 5. Fixed signs in the form of a
« St. Andrew's cross preceded, in the
« case of roads over which the road mo-
« tor circulation is heavy, by an advan-
« ced warning sign, should be considered
« as sufficient protection so long as the
« visibility is good enough.

« 6. In case of insufficient visibility
« — taking into account the speed of
« trains — fixed signs are good enough
« where the number of trains is limited
« and the road traffic is not heavy.

« 7. But if in this case of insufficient
« visibility both traffics are heavy, auto-
« matic signalling is recommended.

« 8. The gates should be retained at
« crossings with very heavy traffic on
« the road and on the railway, when
« the automatic signalling is not suffi-
« cient, and when keepers and the re-
« gulation of the road traffic appear to
« be necessary.

« 9. It is recommendable to facilitate
« the work of the keepers by having the
« trains announced to them by the
« neighbouring signal boxes if they are
« near enough, or by a system of auto-
« matic signals.

« 10. To increase the visibility of the
« signs and of the gates they should be
« painted in stripes of two colours alter-
« nately to make them more striking to
« the eye and they should also, as far
« as possible, be fitted with cat's eye
« reflectors.

« 11. In view of the fact, on the one
« hand, that the organisation of protec-
« tion on the above lines might be very
« costly, and the construction of over
« and under-passages would be even more
« so, and furthermore that the road mo-
« tor traffic at high speed does not select
« the shortest road, but rather a good
« one even if longer, and that conse-
« quently the road traffic is concentrated
« on a restricted number of level cross-
« ings, an endeavour should be made to
« reduce as much as possible the number
« of road crossings with the railways by
« abolishing level crossings with little
« traffic, by diverting the traffic towards
« those which, having a heavier road
« traffic, are fitted with adequate si-
« gnalling systems and warning devices
« or gates, and by building under and
« over-passages at the places where the
« heaviest road traffic is concentrated.
« When drawing up schemes for build-
« ing and rebuilding the roads, these cir-
« cumstances should be taken into ac-
« count.

« 12. Following these ideas, and in
« accordance with the American practice
« (State of New York) the level crossings
« can be classified into three groups :

« I. Unguarded level crossings without
« gates and without automatic signalling
« of the arrival of trains.

« II. Unguarded level crossings without
« gates but with automatic signalling of
« the arrival of trains.

« III. Guarded level crossings with or
« without gates.

« The first category involves the level
« crossings where the visibility on the
« railway is good and where the num-
« ber of trains per day does not exceed
« 100 and the product of the number of
« trains multiplied by that of the road
« vehicles is under 70 000, as well as the
« level crossings with insufficient visi-
« bility, limited rail traffic and light cir-
« culation on the road. »

« The second category involves level

« crossings where the visibility on the « railway is not sufficient and where the « other conditions are fulfilled.

« The third category involves other « level crossings with heavier traffic. « The most important among these are « generally replaced by over or under- « passages.

« 13. As the increase of the diffi- « culties at level crossings has been caus- « ed by the formerly unknown intensity « of the road traffic, the road should « assume the cost of constructing the « over and under-passages as well as « those for the additional protection of « the crossings required by the growth « of the road traffic. »

QUESTION II. — The use of mechanical appliances in the permanent way maintenance and in track relaying.

Summary.

« 1. Although mechanical methods of « maintenance and renewal of the track « have been on trial and in use for some « years, only a limited number of Rail- « way Administrations have adopted « them definitely and generally.

« The time that has elapsed since the « introduction of these methods is very « short and no definite conclusion can be « drawn from the results obtained, al- « though the Administrations using « them have found them convenient.

« The small number of trials may be « attributed to circumstances arising « from the world economic crisis.

« 2. It may be noted that maintenance « work is usually carried out by the « Railway Administrations *themselves*, « while renewals are done by *contract*; « this must not, however, be taken as a « general rule.

« 3. Among the operations successfully « performed by mechanical appliances « the following may be noted :

« *a*) Transport of staff and material « by trolleys;

« *b*) Transport of ballast in special « wagons;

« *c*) Screwing screw spikes;

« *d*) Tamping sleepers;

« *e*) Screwing fishbolt nuts;

« *f*) Sifting and grading ballast;

« *g*) Adzing and boring sleepers;

« *h*) Weeding;

« *i*) Taking off, carrying away, and « laying totally assembled track.

« 4. In view of all this, this interesting « investigation should not be considered « as completed. The subject of this « question should therefore be kept be- « fore future congresses, acknowledging « at the same time that much new in- « formation has become available since « 1930.

« It is hoped that the administrations « carrying out trials will continue to « keep detailed records in order to fur- « ther the solution of the problem of « the comparison of cost between me- « chanical appliances and hand labour. »

QUESTION III. — The relationsship between the vehicle and the track, to ensure safety at high speeds :

A) *Weight of vehicles per axle, position of the centre of gravity, wheel arrangement, layout to facilitate running through curves.*

B) *Track resistance, widening of gauge, radius of curves, superelevation, transition curves, points and crossings, check rails.*

Summary.

A. — THE VEHICLE.

« 1. For high-speed steam locomotives, « guiding by four-wheeled carrying bo- « gies is found to be the general practice. « Two-wheeled trucks are more rarely « used.

« High-speed electric locomotives have « four-wheeled carrying bogies, or bo- « gies with 2 carrying wheels and 2 driv- « ing wheels or two-wheeled trucks, or « a bogie for one direction of running « and a two-wheeled truck for the other, « or again two driving bogies.

« It is recommended that the vehicle « should be guided by the bogie centre « pin only, that a long rigid wheel base « be provided with as long a guided « length as possible.

« For 8-wheeled tenders it is recom- « mended to utilise two bogies.

« 2. Carriages for high-speeds are « preferably bogie vehicles. There is a « certain tendency towards the use of « long wheel base bogies.

« 3. A high centre of gravity of the « locomotive is an advantage as regards « smooth riding. The question of safety « against the locomotive overturning has « been satisfactorily solved everywhere.

« 4. Generally speaking locomotive bo- « gies are provided either with gravity « or spring controlling gear. The initial « centring force should be sufficiently « high and not differ greatly in value « from that of the final centring force.

« 5. Among the various methods of « suspension for locomotives the arran- « gement into two transverse planes, with « the engine supported on three or four « points, most satisfactorily ensures that « there is sufficient static load on the « guiding wheels when entering the su- « perelevation incline on leaving a curve.

« 6. Safety against derailment de- « creases as the diameter of the guiding « wheel, the striking angle, and the co- « efficient of friction increase. On the « other hand the high value for the « angle made by the outer face of the « wheel flange with the horizontal in- « creases the safety. The value of this « angle is however limited by the fol- « lowing considerations : *a*) more rapid « wheel flange and rail wear; *b*) increas- « ed resistance on curves.

« It must be understood that the dia- « meter of the guiding wheel cannot be « less than the limit imposed by the « other elements considered.

« In order to reduce the co-efficient « of friction it is desirable that some « efficient and practical solution be « found of the question of lubricating « wheel flanges when running through « curves.

« 7. The preceding conclusion refers « to the question of security against de- « railment only from the static point of « view. Research work and trials are « now being carried out on several rail- « ways for the investigation of the dy- « namic forces, taking account of the « friction in the suspension gear. Owing « to the importance of the problem, the « Congress recommends the continuance « of these studies and researches.

B. — The track.

« 1. The computation of the strength of « the railway track is especially an ex- « perimental matter.

« Research work undertaken by some « Railways ought to be encouraged and « followed with interest.

« Special attention should be paid to « all trials tending to the elimination of « rail joints — the use of long rails, the « welding of rails, etc.

« 2. The present tendency is to di- « minish gauge widening and to ensure « closer guiding of the vehicles by the « track. Systematic trials, with this ob- « ject in view, ought to be pursued.

« 3. The rules used for determining « the speed through curves, the super- « elevations and the transition curves « between circular curves, vary on the « different railways. These factors, « which affect high-speed running « through curves, could usefully be made « the subject of further research work, « which would take into account the « forces called into play when the ve- « hicles are running.

« 4. Turnouts on high-speed tracks « should be so laid out that as far as « possible no speed restriction will be « imposed when they are run over. »

2nd SECTION. — Locomotives and rolling stock.

QUESTION IV. — Methods to be used to increase the mileage run by locomotives between two repairs including lifting.

Summary.

« 1. One of the chief reasons for lo- « comotives requiring heavy repairs is « the attention which has to be given « periodically to the boiler. It is, there- « fore, obvious that boiler design is of « primary importance, and arrangements « should be made for it to receive suit- « able water, and for it to be washed « out properly.

« 2. Regular and systematic examin- « ations tend to the discovery of defects, « and the renewal of worn parts, and so « prevent casualties and loss of mileage.

« 3. Tyres usually require to be re- « turned between heavy repairs, and, « therefore, every attention should be « given to providing material which will « give as little wear as possible. The « study of the relation of the wear of « tyres and rails merits more attention « than has so far been given to it.

« 4. Intermediate repairs, where tyres, « bearings, etc., receive attention, can « be quickly carried out if systematically « performed, and materially increase the « mileage between heavy repairs.

« 5. There has been a tendency in re- « cent years to obtain a greater mileage « per day from locomotives by various « means; this is an advantage in itself, « and also tends to increase the total « mileage between heavy repairs.

« 6. Where it is possible, and the per- « manent way and loading gauge allow, « it is an advantage to employ locomo- « tives which are ordinarily worked well « below their maximum capacity. The « increased capital cost, however, must « be borne in mind. »

QUESTION V. — Electrification of railways from an economic point of view. Selection of sites for generating stations. Choice of the kind of current. Safety precautions, etc.

Summary.

I. *Electrification from an economic point of view.*

« I-1. Electrification is in general « characterised, from the economic point « of view, by a heavy increase of the « capital charges, by savings, frequently « considerable, on the operating costs, « and finally by indirect advantages « which may in certain cases play the « predominant part; the balance sheet « of the electrification should therefore « include all these elements.

« I-2. It is always difficult to draw « up this balance sheet accurately, owing « to the incertitude that exists as to the « evaluation of certain factors, some- « times of considerable importance.

« I-3. The diversity of the accountancy « methods make it difficult to compare « the balance sheets prepared by the « different administrations, especially as « regards the industrial amortisation of « the fixed plant and rolling stock.

« I-4. As the total capital charges may « exceed the operating costs in the case « of electric traction, whereas they only « represent a small fraction in the case « of steam traction, fluctuations in traf- « fic are capable of modifying radically « the aspect of the balance sheet of elec- « trification.

« I-5. Apart from special cases (su- « burbs of large cities, mountain lines, « lines on which the limit of capacity « has been reached, abnormally high fuel « costs, etc.), electrification is generally « economical only if money can be ob- « tained at an acceptable rate, if the elec- « tric power can be obtained at a favour- « able price, and if the traffic is propor- « tionately heavier as the profile of the « line is easier.

« I-6. The economic considerations « proper to the railway are not the only « ones which may decide the electrifica- « tion of a line : the decision may be « the result of either considerations re- « lating to the general economics of the « country, or necessities of a technical « nature quite apart from any question « of finance.

II. *Selection of sites for generating stations.*

« II. Under reserve of the special re- « quirements of electric traction, the se- « lection of the sites for the generating « stations supplying power to electrified « railway lines is governed by the same « considerations as in the case of gener- « ating stations feeding ordinary distri- « bution systems or large centres of con- « sumption.

III. *Choice of the kind of current.*

« III-1. The choice of the kind of « current for electric traction, formerly « influenced by technical considerations, « is today a problem to be solved either « by purely economic considerations or « by special considerations.

« III-2. This choice can only be de- « termined in each case by taking into « account the whole of the conditions of « the problem put forward, and by com- « paring the whole of the expenditure « (operating costs and capital charges).

« III-3. The three-phase system ap- « pears unlikely to be used for new ap- « plications outside the zones in which « it is already in use, so that in the case « of new electrifications the choice would « appear to lie between direct current « and single-phase current only.

« III-4. Although direct current has « been adopted in recent years whenever « it was not a question of extending an « electrification already undertaken on « a different system, or of electrifying « lines closely connected with others al- « ready electrified on a different system, « the two systems, direct current and « single-phase current, appear to be suit- « able for future use in new electrifica- « tions outside their present fields of « application.

IV. *Safety precautions, etc.*

« IV-1. Apart from the safety measures in general use in all plants using electrical energy, supplementary measures have been taken on electrified lines to protect the public and the staff against the particular dangers which the contact lines (trolley wire or conductor rail) and the electrical equipment of the locomotives and rail motor coaches may present.

« IV-2. The efficacy of these measures is proved by the few accidents which can be ascribed to the use of electrical energy for traction purposes.

« IV-3. Most of these accidents are the result of a mistake committed by the victim, his imprudence or his negligence.

« IV-4. These accidents occur especially when the electrification is new, and principally affect the staff still insufficiently familiar with the steps to be taken to protect themselves, whence the necessity for specially looking after this part of the professional instruction of newly recruited staff, or staff temporarily employed, as well as of staff employed by contractors. »

* * *

Mr. Withington, the American Reporter, who was unable to attend the discussions of the Congress, has pointed out that Summary III-4 does not exactly state the conditions existing in America.

For instance, in the case of the Great Northern Railroad, in the northwestern part of the U.S.A., a decision was made to electrify on the basis of single-phase power distribution, replacing the early three-phase electrification on that railroad. This was not an instance of extending a previous electrification of a single-phase system, as it was necessary to discard practically all the original equipment. As another example : The Reading Company's single-phase electrification recently completed at Philadelphia, is an entirely independent project not connected with any previously existing electrification.

Furthermore, the Pennsylvania Railroad in extending its electrification between New York and Philadelphia, proceeded on the basis of single-phase distribution in spite of the relatively elaborate D. C. system originally installed, and the New Haven Railroad also having had early experience with direct-current, adopted the single-phase system for its main line electrification.

QUESTION VI. — All-metal rolling stock : carriages and wagons. Use of light metals and alloys. Use of autogenous welding.

Summary.

« A. — *Passenger carriages.*

« 1. The favourable results obtained during the last three years with all-metal passenger coaches confirms the summary of the Madrid Congress, wherein the following special advantages were emphasized :

« Greater safety in case of accident;

« Favourable tare weight of the vehicles;

« Possibility of mass production;

« Good interior appearance and arrangement.

« 2. Results so far obtained appear to authorise favourable expectations as regards the life of the vehicles, maintenance costs and redemption of the original capital cost. They justify the expectation that all-metal carriages will prove themselves and produce definite savings, especially in those countries in which the conditions for their use are most favourable.

« 3. The method of construction in « which the underframe and the body « framing are built as one unit which « absorbs the forces developed as a « whole, the weight being reduced at « the same time, has given further satis- « faction. In all-metal construction this « method is used almost exclusively. « Experience has shown that it is neces- « sary to give special attention to the « strengthening of the ends of the car- « riages, in order that, in case of colli- « sion or overriding, they should offer « the greatest possible resistance.

« 4. By the use of high-grade steels « and by the substitution of welding for « riveting, appreciable savings in weight, « as compared with wood or riveted steel « carriages, can be effected.

« 5. The use of light metals and alloys « can also reduce the weight appreciably « and therefore offers advantages in cer- « tain structural parts under specified « conditions, in spite of their high price. « Conclusive evidence as to their beha- « viour over a long period of time is not « yet available. The Congress recom- « mends the use of these materials to be « further investigated.

« B. — *Goods wagons.*

« 1. Metal construction has special ad- « vantages over wood for goods wagons :

« Greater strength;
« Greater safety in service;
« Longer life;
« Lower maintenance costs.

« 2. Under given climatic and oper- « ating conditions covered goods wagons, « whether of the all-steel type or of com- « posite construction, are used success- « fully.

« 3. All-steel construction for special « coal, coke, and mineral wagons is ad- « vantageous.

« 4. By substituting welding for rivet- « ing, appreciable reductions in weight « can be effected.

« 5. The use of iron or of steels of « appropriate qualities and of copper- « bearing steel appears to be an impro- « vement in the way of protection against « corrosion. »

3rd SECTION. — Working.

QUESTION VII. — Allocation of freight rolling stock. Investigation into the turn-round of goods vehicles. Separation of the elements included in it. Methods of reducing the period of turn-round.

Summary.

« The reports presented to the Con- « gress in respect of the allocation of « goods wagons show that in a general « way the Railway Systems are inclined « towards the same solutions, with cer- « tain peculiarities depending on the « traffic requirements.

« What is interesting in the matter is « the tendency towards a scientific or- « ganisation of the allocation with the « object of reducing the period of turn- « round of wagons and to increase the « efficiency of the available stock.

« In this order of ideas, advantage can « be taken of the relative constancy of

« traffic needs and the supply of wagons. « In the large number of cases in which « this constancy is noticed, it is possible « to set up a system of allocation comprising permanent orders for the direction of currents of empty wagons, supplemented in view of important supplies « by other orders varying in accordance « with the traffic requirements. Such a « plan should embody an appropriate « organisation of a train service allowing « as speedy a despatch of wagons as possible, while serving at the same time « the stations with intense traffic at suitable hours for delivery and collection « of wagons.

« The formula for centre-stations recommended in the summary of Question VIII regarding the grouping of « parcels comes within the scope of this « organisation of through trains.

« The improvements made in the telephone service in the form of « dispatching systems » can be used with « advantage for the rapid circulation of « through trains of empty and loaded « wagons.

« Standardisation of the types of wagons, towards which the efforts of « the Railways are directed, tends to « simplify the operations necessary for « the allocation of wagons, and to reduce « the empty running and consequently « to decrease the period of the turn-round of wagons.

« In case of heavy traffic due to « seasonal or exceptional requirements, « the quickness of the turn-round may « call for exceptional measures, such as « the formation of through trains accelerated as necessary, taking into consideration the available locomotive « power, the despatch of empty wagons « by the quickest way by giving them « priority, and the increase of shunting « facilities at the stations.

« In view of the importance of the « quick turn-round of wagons, it is recommended, on the one hand, that the « allocation of wagons should be linked « to the service in charge of the goods « train running and, on the other hand, « a permanent control should be exercised on the way the allocation programmes are carried out, or on the « operations at stations with intense traffic, in order to constantly improve the « efficiency of the rolling stock. »

QUESTION VIII. — Organisation for carrying small consignments of goods and the most suitable methods for their delivery with the least delay. Use and selection of fixed and mechanical transhipping plants.

Summary.

« The reports presented to the Congress on the subject of the organisation of parcels transport bring to « light the efforts made by the Railway « Companies towards a better service of « ordinary and fast goods transport with « the object of improvements called for « by the necessity for retaining this traffic, which is being strongly disputed by « automobile competition.

« Many points arise out of the various « measures taken or suggestions put « forward in respect of rail transport, « and complementary transport from the « premises of the sender to the despatching station and from the arrival « station to the consignee's premises.

« First of all, for the rapid transport « of parcels by rail must be borne in « mind the solution by the employment « of light trains, inaugurated on the « Deutsche Reichsbahn under the title « of *Leichte Stückgüterzüge* and known « on the Italian State Railways as *Treni « rapidi collettame.*

« Alternately, it may be advantageous « to substitute for the multitude of despatching and receiving stations a limited number of centre-stations, commanding operating zones of some extent « and constituting principal points of « departure and arrival for rail borne « parcels traffic, the connections between « the centre-stations being maintained by « rail.

« The object is to group the elements « for making up full wagons or groups, « the transport of which must be effected « rapidly. The concentration of packages at the centre-station or the distribution at the secondary stations may « be carried out either by road lorries or « by rail cars designed in such a way as « to make economical transport, or even « by means of a simple shunting engine, « e. g. a loco-tractor.

« In regard to complementary transport, it is essential that the railway « endeavours to realise, as far as lies « in its power, the convenience that the « automobile service offers to the public, « especially door-to-door transport.

« The use of containers for groups of « packages, which cannot fully load a « wagon, has constituted an improvement; this should be followed up and « extended, especially in international « traffic.

« For single packages, the system « should be developed of collection at « private houses and at receiving offices, « the number of which should be increased in the big towns. This programme may be be carried out either « by Express Companies or by the Railways themselves, by means of lorries « equipped in an up-to-date manner, in « order to meet the demand for greatest « rapidity both in transport to the station « and delivery on arrival.

« In this respect it is useful to unify, « on any one System, the scale of cartage « charges, with a view to facilitating the « work of the public, always worried by « the complication of documents.

« With the same object in view, it may « be advantageous to look for new formulæ for rate making, based on the « practice of the automobile services. « For example, when hiring to Express « Companies, Factories, or Merchants, « wagons to be transported, whether full « or empty, on a kilometric basis, the « senders would come to prefer the use « of wagon and rail transport to transport by lorry. The Express Company « would have a representative in charge « of the distribution of the packages to « the consignees, and would, moreover, « be induced to canvass for return « freight.

« To sum up, every means should be « employed to enable the Railway to render the services that the automobile « offers to the public, not only by modernising its methods but also by encouraging its employees to influence « the public in such a manner as to retain and secure traffic and to direct « the minds towards a more exact comprehension of the general economy. »

QUESTION IX. — Automatic train control and train stop. Track equipment. Locomotive fittings. Methods used for repeating signals on the locomotives. Devices intended to ensure the attention of the drivers.

Summary.

« 1. The desirability of equipping a « railway system or individual lines with « train control apparatus depends « amongst other things upon the train « speed, the intensity of the traffic, the « interval between signals and the cost « of installation.

« Automatic train control is an important complement to the safety precautions. Its introduction is recommended on routes where it appears necessary in the light of the above considerations.

« 2. Train control can be effected in two ways :

« *a*) By a simple repetition of the signals on the engine;

« *b*) By direct action on the brakes to cause stoppage or reduction of speed.

« The two devices can be utilised jointly.

« 3. In both cases train control should be regarded as an adjunct to the existing signalling equipment. It is intended to ensure the observance of signals in all cases where the driver fails to take notice of them, or to avoid the consequences resulting from such failures. But, in the main, safe running has to be guaranteed, as in the past, by the alertness of the driver, and it is important that this alertness should not be interfered with. It is therefore recommended in general not to remove fixed signals on lines provided with automatic train control.

« 4. The continuous inductive system of automatic control is capable of meeting operating and safety requirements to a somewhat greater extent than the intermittent inductive system. Sufficient information is not yet available to form the basis of a decision as to whether this advantage is or is not outweighed by the higher cost and greater delicacy of the continuous system. The most important operating and safety conditions can be met by the intermittent system. The continuous system should be considered simply in connection with lines equipped with automatic signalling.

« 5. The purely mechanical method of transmission has proved a reliable method of conveying intermittent impulses from the track to the locomotive on Metropolitan systems. Where snow or other deposits on the track are liable to cause disturbances, it is desirable to arrange the transmitting apparatus at a suitable height above rail level. Difference of opinion exists as to the suitability of the purely mechanical system of transmission for fast train routes.

« 6. The electro-mechanical system of transmission using contact ramps has given satisfatory results in countries having temperate climates (Western Europe); in some cases, however, protection has to be provided against hoar frost. An essential condition for the employment of the electro-mechanical design is the existence of ample clearance between the underside of the vehicles and the track.

« 7. Various electro-inductive systems have proved reliable and not sensitive to climatic conditions on fast train routes.

« 8. With the continuous inductive automatic control, only inductive transmission by track circuits can be considered at present.

« 9. An advantage of the electro-mechanical and the inductive types of equipment, as compared to other designs, is that they do not require any operating gear on the track. In certain types of inductive equipment, it has been possible to dispense with a local supply of current.

« 10. The adoption of the closed circuit principle in such a way that any « failure would produce a warning indication is to be preferred on grounds « of safety.

« 11. The chief object of automatic « train control is to stop the train if a « home signal is at danger. It is desirable to so design the equipment, that « safeguards can be applied to ensure « reductions of speed at junctions and « other places where such restrictions « are stipulated. Systems which give « several kinds of impulses are specially « suitable for this requirement.

« 12. In cases of railway services in « which short braking distances are the « rule, the consequences of the driver « failing to comply with signals can be « fully averted by an automatic control « transmitter at the home signal, provided that the impulse causes the brakes « to be applied immediately, and that the « distance between the home signal and « the danger point is at least equal to « the full braking distance.

« As a rule these conditions are not « fulfilled on fast train routes; first of « all, therefore, an automatic control action before reaching the stop signal is « essential in such cases.

« 13. In types in which action begins « before reaching the stop signal, a simple repetition of the signals on the « locomotive, together with the device « for checking the alertness of the driver « and the recorder, can be considered « as sufficient. In this way the more « important factor of safety is secured « without interfering with the work of « the driver.

« 14. On railways which have not « adopted the preceding system, it is desirable that the application of the « brakes shall also occur with automatic « control transmitters before reaching « the stop signal, in order to obviate the « possibility of the driver making a « mistake after passing the distant signal.

« Only when danger exists, however, « should braking be continued up to the « point of complete stoppage; contrariwise, when the driver is running according to regulations, control of the « speed should remain in his hands.

« 15. For checking the alertness of the « driver, either a vigilance checking device, or an arrangement for graded « speed checks are available. The vigilance check in the vicinity of the distant signal can be supplemented by a « speed check that comes into operation « later.

« 16. The vigilance checking device « must enable the driver to prevent the « brakes coming into operation in the « neighbourhood of a distant signal. It « may be an advantage, from the point « of view of maintaining smooth operation, if, in addition, it is possible to « release the brakes subsequently. However, the alertness of the driver is better guaranteed if braking continues to « the point of standstill, after he has « failed to apply the vigilance checking « device, and the release of the brakes « can only be effected when the train has « stopped.

« 17. With a view to maintaining proper supervision over the use of the « vigilance checking device, and the « existence of the control impulses, it « is desirable that recording apparatus « should be fitted which should, if possible, record the speed and indicate the « location at which each event has occurred.

« 18. Designs which embody uncon-
« ditional braking at a danger signal re-
« quire a cancelling-out device, so that
« in the event of signal failures, it may
« be possible to run past a signal which
« is at danger.

« 19. It must be possible for the driver
« to cut out the automatic control appar-
« atus in the event of faults occurring
« in the equipment on the engine. »

4th SECTION. — General.

QUESTION X. — Instances of the application in a railway department of the scientific organisation of work. Co-operation of the staff towards increased efficiency and its participation in the profits.

Summary.

« 1. At the base of rail transport or-
« ganisation is the general organisation
« of all means of transport, but to enable
« each to cater for its own traffic, the
« legal and fiscal obligations should be
« the same for all carriers.

« This condition being fulfilled, the
« harmonious co-ordination desired must
« be sought for from the outside by ef-
« fecting all possible connections be-
« tween rail and other means of trans-
« port (road motors, mechanised inland
« water transport, aeroplanes) and also
« be pursued internally in each service,
« system and group of systems, in order
« to increase efficiency. It should be
« noted, however, that amalgamation, to
« which in certain cases co-ordination
« may lead, is limited, both as regards
« management and actual operation, by
« various circumstances.

« 2. The results which it is hoped to
« achieve from organisation not being
« entirely dependent upon the railways
« themselves, it is necessary if the ef-
« forts made are to have really satis-
« factory results, that the administrative
« obligations to which the railways are
« subjected and the regulations by
« which they are governed should be
« properly adapted to the existing econ-
« omic conditions and the increased
« technical possibilities of new ap-
« pliances.

« 3. The aim of modern organisation
« should be to carry out all mechanical
« work by machinery, leaving to the
« human being those tasks which require
« initiative and discernment.

« Such organisation increases the sa-
« fety of the employees, both by the
« abolition of certain work involving
« special risk, and by the introduction
« of devices which safeguard the oper-
« atives against the consequences of hu-
« man fallibility.

« Finally, the organisation of work
« together with the award of output pre-
« miums or shares in the general profits
« of the undertaking makes it possible to
« assure an increased remuneration to
« the staff.

« 4. The duties of controlling offices
« must be clearly defined and be sim-
« plified as much as possible, with a
« maximum of direct contact between
« each other and between them and the
« services under their direction so as to
« expedite to the utmost all matters dealt
« with.

« A means of ensuring inter-service « contact which can be recommended is « the holding of periodical meetings be- « tween officials responsible each of part « of a common task.

« 5. The operative services should be « enabled to collaborate in the endeavour « to discover more economical and re- « liable methods. In view of the satis- « factory results already obtained in this « connection, it would be desirable to « extend standardisation of stock as far « as possible, reducing the number of « types and standardising parts and the « tolerances allowed therefor.

« The various workshops and establish- « ments should be organised on the same « lines, adopting the principle of respons- « ible specialisation, whilst not curbing « the initiative of the staff. The organ- « isation of work presents a similar as- « pect for all railway systems, and it « might be of value for the railways « to interest themselves in the work of « the national and international bodies « in connection with scientific organ- « isation.

« In this respect it appears that the « improvements to be effected consist « in the first place in the simplifi- « cation of the operations themselves, « and secondly in the improvement of « the plant. Finally, a prime factor to « be kept in mind for the efficient or- « ganisation of work is the employment « of staff physically fit to perform their « allotted duties, and it is for this rea- « son that attention is drawn to the « development of the psycho-technical « examination already introduced by a « certain number of administrations.

« 6. The preceding measures concern- « ing the material conditions of the or- « ganisation and preparation of work « appear to require the addition of a « moral factor in the shape of the con- « fident collaboration of the staff bring- « ing with it a spontaneous display of « collective good will, based on reciprocal « esteem and equitable remuneration ac- « cording to the efforts exerted and the « results obtained.

« It is considered that for determining « this remuneration, the premium sys- « tem, already made use of, should be « developed. Under this sytsem, pay- « ment consists of two elements : one « fixed and the other varying with the « quality and quantity of the work done.

« The premium should first be intro- « duced at the base, that is for the ele- « mentary operations and be so applied « as to remunerate speedily the efforts « of each employee and in particular « the economies realised in regard to « time taken and material consumed and « the general efficiency of each estab- « lishment.

« 7. From the reports it appears that « no administration strictly speaking « grants participation by its staff in the « benefits of the undertaking.

« Certain administrations distribute « among their employees sums calculated « on the general results of their working « or on economies realized. Some of « them consider that favourable results « can be anticipated from now onwards. « However, this scheme is very recent « and limited to a small number of ad- « ministrations, and it is not yet pos- « sible to draw final conclusions on this « matter.

« 8. As brought out in the summaries « adopted by the Congress in 1930, in « connection with question XVI of its « agenda, it is necessary for railway em- « ployees to be well versed in their pro-

« fession and also to have a good general « knowledge.

« Technical schools and educational « schemes of all kinds instituted by the « railways for the instruction of their « employees are therefore of first class « utility for the improvement of the « railways, and their importance should « not be underestimated.

« 9. For increasing the feeling of con- « fidence and the security of the staff « it is desirable that social and welfare « work should be extended.

« These measures, which are outside « the scope of the actual employment, « are aimed at maintaining the physical « wellbeing of the employee and his fa- « mily and assisting their material ex- « istence right down to the small detail. « They result in the staff being more « devoted to their work, more relieved of « daily cares, and can therefore be high- « ly conducive to the attainment of im- « proved efficiency of the railway sys- « tem. »

QUESTION XI. — Competition between or joint working of railways and airways, or railways and roadways.

An investigation from the technical, commercial and contractual points of view.

Summary.

« 1. — *Railways and road.*

« 1. The question of automobile com- « petition, which was made the subject « of very serious consideration during « the Madrid Congress, is still far from « receiving the solutions recommended « in the summary of 1930. These must, « therefore, be maintained in their en- « tirety inasmuch as, judging from the « reports produced at the present Ses- « sion, the development of goods trans- « port by road has been much increased « by the perfectioning and the extension « of the use of the road lorry. The con- « sequences are as troublesome to the « great Systems as to the Railways of « local interest.

« 2. In every country the railways have « been seriously handicapped in their « efforts to preserve and increase their « traffic by the unequality of the con- « ditions governing transport by road « and by rail. Since the commence- « ment of their existence, the railways « have been the object of much legisla- « tion on the subject of precautions to « be taken in the interests of safety, « conditions of transport, the right to « establish rates and the publication of « tariffs. This legislation was justified « at its origin by the theory that the « railways enjoyed a virtual monopoly, « and that it was, therefore, necessary « to protect the public in different « ways; it continues to be so for the « consideration that the railways should « serve the general interest.

« 3. The result is that the railways, « which have heavy expenses — especial- « ly for the maintenance and improve- « ment of the permanent way — are « subject as well to taxation, particular- « ly heavy in certain countries, and to « heavy obligations in respect of trans- « port and of safety, whereas the auto- « mobile undertakings have every liberty « in fixing their schedules and their « rates as well as in their choice of « traffic. They use this liberty to take « the cream off the traffic normally re- « munerative to the railways, which « leads to the inevitable consequence of « obliging the latter, in order to save « disaster, to increase, to the great pre- « judice of the general economy, the

« tariffs now in force upon heavy mer-
« chandise or goods of first necessity.

« The automobile road transport un-
« dertakings escape, in addition, in great
« part the expenses and obligations of
« the railways, often even in regard to
« the conditions of remuneration and
« work of their personnel. They even
« benefit in some countries from great
« tolerances in the application of the
« road police regulations affecting them,
« and from customs facilities at the
« frontiers.

« However, the railway has, like every
« other undertaking, right to a fair dis-
« tribution of obligations and expenses.
« If this idea of equity cannot be re-
« solved in the same manner everywhere,
« the tendency must manifest itself in
« each country according to its own con-
« ditions.

« 4. The statements presented to the
« Congress indicate a certain number of
« measures adopted in different coun-
« tries with the object of establishing
« a certain equality between the two me-
« thods of transport.

« Since, measures of the same nature
« have been taken in some countries, or
« are on the verge of being put into force
« in others.

« It is certain that unregulated com-
« petition between forms of surface
« transport is extremely prejudicial and
« causes economic losses, and that the
« low cost of certain types of road trans-
« port is more apparent than real, in
« view of the fact that the high cost of
« the roads is not equitably supported
« by the road transport, but recoils on
« the public. In other words, the road
« transport industry in this way is sub-
« sidised by the rate-payers.

« 5. First of all, it is necessary that
« the State should lighten the regulations
« imposed on the railways to allow them
« to modernize their methods, with a
« view to giving the public the same
« satisfaction as the automobile, without
« their being obliged to have recourse
« to a tariff war which would be dis-
« astrous for the general economy.

« 6. The condemnation of such a tariff
« policy brings logically in its train
« measures affecting public transport by
« automobile. To avoid the competition
« prejudicial to the national general econ-
« omy, to maintain public automobile
« transport in the form of a normal use
« of the road, to regulate its organisation
« and circulation as the execution of a
« public service requires, these are the
« measures that are not contrary to pro-
« gress and which would conciliate the
« interests concerned if direct under-
« standings could usefully intervene
« between the railways and public road
« transport undertakings.

« Co-ordination would leave each me-
« thod of transport to fulfil its own role
« for the good of the public and the aim
« of regulation would be purely policing.
« But such direct understandings are
« generally made difficult by the dissem-
« ination of road transport and its par-
« ticularism.

« The railways have notwithstanding
« endeavoured in every way to co-ordin-
« ate the two methods of transport. In
« countries like Great Britain, where the
« railway companies did not possess ge-
« neral powers for operating road ser-
« vices, these powers have now been
« granted.

« In a general manner, it may be said
« that, whether by means of road trans-
« port services run directly by the rail-
« ways, or by agreements with the auto-
« mobile lines, the railways have en-

« deavoured to co-ordinate the two ser-
« vices so that :

« *a*) The one becomes an affluent of
« the other, especially in the case of
« passenger transport;

« *b*) Transport of goods from door to
« door may be effected by the creation of
« well organised collection and delivery
« services.

« 7. The railways have not ceased to
« take measures for improving their or-
« ganisation.

« They have accelerated their passenger
« services. They have often themselves
« utilised automobiles. They have gone
« into the question of general employ-
« ment of rail motor cars, which con-
« stitute in some cases economic, rapid
« and comfortable means of transport.

« Some railways have not hesitated to
« go to heavy expenses in electrifying
« lines with heavy traffic, giving them
« an up-to-date signalling.

« As regards the good services, the
« railways have also remarkably acceler-
« ated the rapidity of transport and have
« reduced delay in delivery. They have
« organised door to door services.

« They have had recourse to the use of
« containers.

« They have given to users the facility
« of warehousing goods in the goods sta-
« tions.

« 8. To sum up, it is necessary that the
« railways continue the efforts they have
« made to still further perfect their
« working methods, but it is necessary
« that they also receive from their Go-
« vernments the help and guarantee
« necessary in consideration of the gene-
« ral interest.

« For this purpose, the Congress re-
« cords the following resolution :

« The public service by rail, constitu-
« ting a national utility which has wholly
« preserved its value, fulfilling an econ-
« omic and social role, the advantages
« of which extend to all classes of the
« public, have the right to obtain from
« their Governments equality of legal and
« administrative regime for all methods
« of transport, as well as of the fiscal and
« other charges which they bear.

« It is, furthermore, incumbent on the
« Governments to ensure that means of
« transport shall be co-ordinated and to
« employ every possible means so that
« this co-ordination be realised without
« further delay, in a spirit of progress
« for the whole of the country.

« 2. — *Railways and airways.*

« Air transport, in its present state,
« does not present the same aspects of
« competition.

« In a general way, the aeroplane consti-
« tutes, for very long distances, such pro-
« gress that the railways can only con-
« tinue to facilitate working together with
« the aeroplane.

« There are, however, certain cases in
« which the State, by reason of subsidies
« granted to aeroplane services, should
« intervene in fixing the charges for
« transport, to avoid the competition of-
« fered to the railways.

5th SECTION. — Light railways and colonial railways.

QUESTION XII. — Co-ordination of operation as between heavy and light railways.

Summary.

« 1. The most essential principle which « must govern all co-ordination, and in « particular co-ordination between main « and light railways, is first of all the « defence of the public interest, that is « to say, the safeguarding of the public « economy.

« 2. The interests of the railways « should coincide with the general in- « terest of the nation : this is the prin- « cipal criterion for any sound railway « co-ordination.

« 3. It would be desirable to abolish « taxes imposed upon the transit of « goods, in cases where they would result « in the turning away of traffic which « otherwise would be handled by rail- « ways.

« In this respect it would be worth « calling the attention of Governments « to the need for a rapid examination in « each case, and to authorise provision- « ally the application, of special rates or « common tariffs proposed by railways, « as is done in some countries. Only « these measures will permit to con- « tinually follow up the requirements of « the traffic. »

QUESTION XIII. — Use of rail motor cars on secondary railway lines.

Summary.

« 1. The use of rail motor cars which, « up to the present, has only provided « a solution of the question in isolated « cases, lends a new interest to the con- « sideration of automobile competition, « the development of which is occupying « the close attention of all Railways, not « only the large Companies but also those « of local interest.

« 2. The rail motor car can be con- « sidered as one of the systems of trac- « tion fulfilling the needs of lines with « little traffic and responding best to « the need for reduction of working « costs, especially when the vehicle can « be driven by one man only.

« The present tendency in the con- « struction of rail motor cars is towards « the use, more and more extended, of « heavy-oil motors and the employment « of more powerful cars.

« 3. Rapid transport, which the road « automobile endeavours to provide, re- « quires, to be adopted in a practical « manner on secondary lines, an en- « gine capable of increased commercial « speeds, and with a cost such that the « volume of the traffic can be increased « without extra charges.

« 4. The rail motor car should be an « easy working and comfortable machine, « specially capable of quick stopping and « starting, getting up speed rapidly, and « possessing a reserve power sufficient « to avoid the constant working of the « motors at their maximum capacity.

« In some cases the reserve power « could be utilised for drawing a trailer.

« It would be advantageous, particu- « larly for short journeys or for shuttle « services, to have a rail motor car that « can be run in both directions.

« 5. The employment of the rail motor « car can also be considered on the main « lines, for a better local service. »

NEW BOOKS AND PUBLICATIONS.

[656 .2 (02]

MAISON (Ferdinand), Inspecteur général des Mines, Directeur honoraire du Contrôle de l'Exploitation Technique des Chemins de fer, Professeur à l'Ecole Nationale Supérieure des Mines (Paris). — **Exploitation technique des chemins de fer (Technical Operation of Railways).** One vol. in-4°, square, of 372 pages, with 270 figures in the text. — 1932, Liége, Librairie Polytechnique Ch. Béranger, 1, quai de la Grande-Bretagne. (Price, bound : 225 Belgian francs.)

The author in his introductions defines what is known as the *technical operation of railways.* It forms that part of the operating service which covers the whole of the arrangements made to organise the trains, and to ensure their safety. On the French railways, it corresponds to the train working service and to the technical services responsible for the *signal boxes* which are under the operating department as regards the programme of requirements and under the permanent way department as far as the construction is concerned. It also covers the study of the *technical regulations governing the working of the railways.*

The book begins by considering this last question. It then deals with the *regulations relating to the movement of trains,* the *signals,* the regulations dealing with the *braking of trains by handbrakes,* the *block system,* the methods of *working single lines,* the *interlockings,* the *organisation of the train service,* and finally the *regulations governing the work of the railway staff.*

The work is divided into seven chapters.

The first chapter, entitled *Regulations concerning the operation of the railways* defines the different classes of railways and examines the principles and requirements of the regulations which are used as the basis of the technical regulations on operation in France. If describes the systems, which differ considerably, in force in other countries.

Chapter II, entitled *train movements* gives the conditions as regards capacity and safety of single and double lines. It contains interesting considerations on the effect of starting and slowing down, on the average speed, and the consequences of stops on the traction costs and the power of the engines.

Chapter III deals with the *Signals.* A description of the French signalling is given with particulars of its application in different examples at stations and junctions.

Without mentioning the Alsace-Lorraine Railways, which were signalled by Germany on the system in use in that country, there are differences as between the different French railways, both as regards the form of the signals and their meaning. These differences are explained by the circumstances under which the railways were created and have since developed because of the desire of the Inspecting Authorities to leave the railways sufficient liberty and initiative so as not to interfere with progress, nor to impose excessive expenditure.

Modifications are being introduced, however, to meet the principles of the *new French signalling system,* the object of which is to get greater standardisation, simplicity and definiteness. The meaning of the colour lights has been revised, with the idea of ensuring a

very simple system of signals at night, so as to help the *development of light signalling by day and night;* it has however been considered essential to make the necessary modifications to the optical signals in order to make them agree with the day and night light signals.

The author also gives the essential features of the Belgian, English, German and American signalling systems.

Special attention is devoted to the repeating of signals on the locomotives, and to the complicated question of automatic train control.

The *regulations on the braking of trains,* the subject of Chapter IV, contain particulars of the development required by the introduction of continuous brakes on goods trains. It has been found necessary to allow for the delay in filling the cylinders through the use of the new type triple valves, for the reduced coefficient of friction of the brake shoe as the pressure increases and of the possible future braking of the load. The author describes the experiments made or being made and gives the constants provisionally adopted by the French railways.

The hand braking problem continues to remain with us in the case of passenger trains on which the continuous brake may fail or in the case of mixed or goods trains not fully fitted. The author sets out the theory and gives the formulæ for hand braking and shows their applications when drawing up the braking regulations.

The methods of *operating double and single-track lines,* the subject of Chapter V, have as their essential object the protection of the trains on the line. The principles and application of the block system with the description of the special block apparatus occupy the principal part. The author could not pass over the automatic block system which has already been applied in France in many instances, either in conjunction with mechanically operated signals on surface lines or with light signals as on the Metropolitain and Nord-Sud railways in Paris. He sets out the principles and leading features on lines with earthed rails or carrying current, with signals normally clear and signals normally at danger.

Chapter VI, entitled *Study of interlocking,* is the one given most space. It contains in the first section the theory of interlocking which may be considered as dealing with the subject fully, the description of the mechanical interlockings on the Vignier, Stevens, Saxby and Farmer systems and that of the mechanically or power operated appliances most widely used in France. The last section describes the application of the interlocking in a box. A certain number of interesting interlocking schemes are dealt with as examples.

The *train service,* the object of the 7th and last chapter includes the study of timetables which should be drawn up with a view to meeting the needs of the users, whilst taking into account the movement of trains over the lines and endeavouring to make good use of the rolling stock and locomotives.

Considerable information is given on the services connected with the trains, the utilisation of the train staff, and of the rolling stock.

Finally the author reviews the regulations governing the working conditions of the railway staff and describes the principal features.

The applications of mechanical and electrical equipment on the railways are many and varied : the operating conditions vary considerably from one country to another, just like their mentality and customs. Certain aspects of works of this kind inevitably apply to particular cases. The analysis of the regulations, the selection of the appliances and safety equipment, the description of which is illustrated, and the discussion

of the principles are naturally inspired by the usual practice of the French railways. This remark in no way lessens the great value, both scientific and technical, of Mr. MAISON's work.

The theories developed, such as those relating to braking and interlocking, and also of the block system, are of absolutely general bearing, and those engineers who cannot find in it any description of the most widely used appliances on their own lines will nonetheless find the same general principles dealt with. The work is undoubtedly useful for all engineers who have to deal with the technical and safety regulations of railways, whether as representing public authorities responsible for the control of the railways, or as officials of the railways. The author must be thanked for having published the courses of lectures he has given with such authority at the Ecole Nationale Supérieure des Mines, Paris.

E. M.